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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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SOME NOTES ON HARDENING SCREW GAUGES.

By J. H. LAVENDER.

THE present article is written, not in any way as a complete treatise on the above-named subject, but with a view to assisting those interested in the more rapid production of the hardened gauges which will pass the National Physical Laboratory test. The following particulars have been obtained from experimental work conducted over a period of six months, but there is still much to be done to establish figures for varying brands of steel.

The heat-treatment has been controlled from the laboratory, but the gauges have been hardened, with certain precautions, in the ordinary way in the hardening shop. Now, the essential requirements of screw gauges, as far as they are affected by heat-treatment, are :—

(1) They must not change in shape (become oval).

(2) They must not change in size (increase or decrease in volume).

(3) They must retain good surface after treatment.

If a gauge changes in shape and becomes oval, grinding, which is extremely difficult, is necessary or it is worthless. If a gauge changes in volume and becomes smaller, it is useless; if larger, "lapping" is necessary.

A good surface, whilst not as important as absence of change of shape or size, considerably adds to appearance and worth of gauge. The object of this research was the production of a gauge, well hardened, accurate to size, and with a sufficiently good surface, so that it would not be necessary even to polish after hardening.

The first assumption made was: "Provided there is no internal strain in the steel used, it is reasonable to hope that all gauges made in cast steel will give similar results under similar heat-treatment." This was found to be partially correct when the steels were of approximately the same chemical composition. Different cast steels give different results. Some appear to shrink, whilst others appear to expand, but gauges made from the same bar of steel give practically identical results. In the early stages of the work some difficulty was experienced, and a number of gauges scrapped, owing to their being made from different steels. As a result of this it was decided that, until definite results were established, each gauge should be analysed for carbon and manganese before heat-treatment.

From a number of preliminary results on different brands of cast steel, one having a high percentage manganese was selected because :—

(*a*) The manganese content of the steel appeared to affect the volume changes in the steel.

(*b*) This particular brand of steel could be quenched in oil, and a better surface finish obtained than from one quenched in water. The steel analysed gave the following results :—

	Per Cent.
Carbon	0.96
Silicon	0.19
Manganese	1.20
Sulphur	0.03
Phosphorus	0.02

Furnace.—The furnace used for heating the gauges need not be of any particular kind, as long as the metal is not heated too rapidly and uniformity during heating is obtained.

Some months ago, in order to improve the surfaces of gauges, a small furnace having a reducing atmosphere (coal gas) and a direct passage to the quenching tank was designed. From this furnace a number of hardened gauges having a very good surface were obtained. However it was found that quite as good results could be obtained when hardening from an ordinary furnace. A small Richmond gas furnace is very suitable for the work.

Heat-Treatment.—It is well known that steel expands more and more as the temperature rises, and since in gauge work no change in volume is allowed, the quenching must take place at the lowest possible temperature, *i.e.*, least volume expansion, at which correct hardness can be obtained. Now in order to find this exact temperature, pyrometric curves of the steel were prepared, and the Ac. (calescence) and Ar. (recalescence) points carefully noted. From these curves it was decided to harden gauges from a temperature of 749 deg. C.; this temperature is sufficiently high to provide a fair margin for the hardener, and at the same time it will secure a well-hardened gauge. Gauges quenched from this temperature are quite hard, and cannot be cut by means of a file.

Quenching.—Whale oil is used for cooling purposes. This, of course, must be at a fairly low temperature, say about 30 deg. C.

Note on Oxidation.—In order to prevent undue oxidation of gauges taking place during hardening, also during transference from furnace to quenching tank, it is necessary to keep them from contact with the air as much as possible. This is done by providing for a reducing atmosphere in the furnace by means of excess of gas, and also arranging for the quenching tank to be as near as possible to the furnace.

Tempering.—Gauges are tempered in oil at 260 deg. C., sufficient time being given for obtaining uniform temperature throughout the metal.

The volume changes which take place in the steel during the above detailed heat-treatment can be best followed from the results obtained.

Fig. 1.

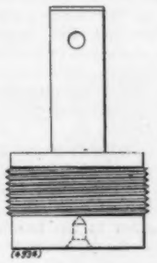
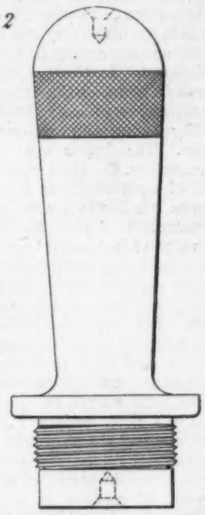


Fig. 2



The gauges were measured for all dimensions in the tool room by means of a simple micrometer instrument and Millward needles. The top, effective and core diameters were supplied to the laboratory. The following figures were obtained in July from almost the first heat-treated gauges :—

Part.	Before Hardening.	After Hardening.	After Tempering.	Measured Again	
				Sept. 18.	Nov. 18.
A.					
Top	1.1997	1.2009	1.1999	1.2000	1.2000
Effective ..	1.2170	1.2170	1.2160	1.2159	1.2159
Core	1.4640	1.4655	1.4647	1.4647	1.4647
B.					
Top	1.2000	1.2011	1.2002	1.2002	1.2002
Effective ..	1.2170	1.2170	1.2158	1.2157	1.2157
Core	1.4640	1.4652	1.4642	1.4641	1.4641

The gauges were slightly oval on some of the dimensions.

It will be noticed from the figures that the greatest change has taken place in the effective diameter. The true result is not clearly shown until after tempering. This change in the effective diameter results from one or two causes. Either it is due to expansion or oxidation. With regard to the former, as previously stated, the metal expands during hardening, expansion takes place in all directions, so that in the case of a plug gauge, such as shown in Fig. 1, the expansion of the steel causes an opening out of the threads, and a consequent relative drop in the effective diameter. If the gauge be heated in an upright position, as shown in Fig. 2, and the design be such that the weight of the metal above the thread gauge be large, the effective diameter does not drop so much, because, during heat-treatment, expansion—which causes opening out of the threads—is partially prevented by the weight of metal pressing downwards. As regards oxidation, this also accounts for drop in effective diameter. However, much work has been done since the above figures were obtained, and it has been found that if the above-mentioned precautions are taken no oxidation will occur. Now, the sudden cooling of the metal during quenching prevents the steel from regaining its original size, and therefore until tempering has taken place there is considerable strain in the gauge owing to its tendency to get back to its former size. On tempering, this strain is done away with, and the gauge resumes its normal dimensions. The sizes for machining of gauges at the present time are arrived at from the figures previously given (due allowance being made for shape of gauge) and the later successful work in overcoming oxidation. Final figures are now being obtained somewhat as follow :—

Gauge Hardened.

Part.	Nominal Size.	Before Hardening.	After Hardening.	After Tempering.
Top	1.2000	1.1992	1.2008	1.1998
Effective ..	1.2170	1.2170	1.2180	1.2170
Core	1.4641	1.4633	1.4650	1.4640
Gauge Hardened.				
Top	1.2000	1.1992	1.2008	1.1999
Effective ..	1.2170	1.2170	1.2175	1.2169
Core	1.4641	1.4633	1.4650	1.4640

The above results, which, as can be seen, come within the National Physical Laboratory's requirements, have all been obtained under ordinary workshop conditions. However, it is essential that the hardening be in the hands of a reliable man who will carefully follow instructions given to him. The present article gives particulars for plug gauges only. Figures for ring gauges have not yet been finally established.

In conclusion the author begs to acknowledge his indebtedness to Messrs. E. G. Wrigley and Co., Limited, of Birmingham, for the facility granted him in enabling him to carry out the above research.

AMERICAN IRON AND STEEL.—The exports of iron and steel from the United States in the nine months ended September 30 this year amounted to 4,358,189 tons, as compared with 2,461,198 tons in the corresponding period of 1915. Billets, ingots, and blooms figured in these totals for 1,051,669 tons, as compared with 407,901 tons; steel bars for 588,753 tons, as compared with 298,335 tons; pig-iron for 302,504 tons, as compared with 156,929 tons; wire nails for 114,710 tons, as compared with 66,434 tons; wrought pipes and fittings for 111,238 tons, as compared with 92,230 tons; steel rails for 391,449 tons, as compared with 219,494 tons; steel plates for 196,494 tons, as compared with 164,995 tons; structural iron and steel for 211,869 tons, as compared with 165,905 tons; tin and terne plates for 179,126 tons, as compared with 105,065 tons; barbed wire for 341,919 tons, as compared with 172,974 tons; and all other wire for 211,566 tons, as compared with 168,061 tons. In the nine months ended September 30 this year American exports of iron and steel exceeded the high record of 1915 by no less than 147 per cent. While American iron and steel exports increased so largely this year the imports of iron and steel into the United States to September 30 declined to 203,025 tons, as compared with 392,518 tons. Steel rails were imported in the first nine months of this year to the extent of only 24,438 tons, as compared with 60,646 tons. The imports of ferro-silicon sunk to 5,071 tons, as compared with 220,848 tons.

FIJI.—Telegraphic communication is maintained between Suva and Levuka, a distance of 54 miles, of which 11½ miles are represented by a submarine cable. There is an overland telephone line from Suva to Lantoka, a distance of 125 miles. The line from Suva to Ba is controlled by the Government, the Colonial Sugar Refining Company, and the Union Steamship Company. From Lantoka the Colonial Sugar Refining Company has extended its line towards Sigatoka. There are three wireless stations in the group, at Suva, Labasa and Taveuni. These stations have been erected at the charge of the general revenue, and they are controlled by the Colonial Government. A new station at Tulagi, in the Solomon Islands, has been brought into operation; the strength of the signals is good, taking into account the fact that the mountains of Viti Levu intervene. The Pacific Cable Board has a cable station at Suva, which is connected by cable with Vancouver via Fanning Island, and with Southport (Queensland) and Auckland via Norfolk Island. The telegraph stations at Apia (Samoa) and at Tutuila (American Samoa) have latterly communicated direct with New Zealand and Honolulu. The main triangulation of Vanua Levu has been completed; the final results, however, are not yet available. Several public works were completed in 1915. The most important was the Ba river bridge, 744 ft. in length; this was completed in a year. Harbour works were delayed in consequence of a subsidence of wharf piles, but it is expected that by the end of this year there will be one berth for a large steamer and one on Walu Bay frontage for a smaller vessel.

THE NAVAL WAR AND THE SIZE OF BATTLESHIPS.

By William Hovgaard, Brookline, Mass., U.S.A.

(*Concluded from page* 604.)

The Military Aspect of Size.

Having discussed the influence of size on the technical characteristics of battleships, we shall now, on the basis of that study, examine its influence on the military value of vessels of this class.

Larger size allows of higher maximum and cruising speed under all conditions of the sea as well as greater radius of action, i.e., it enhances the mobility, which, from a strategic point of view, is the most important quality of warships. Great mobility permits a wide deployment at the strategical centre of concentration, because the scattered forces can be quickly condensed whenever needed. It, in other words, enables a fleet to disperse, with the consequent advantage that a more extended area of the theatre of war can be covered. High mobility allows also rapid transfers of the naval forces to be made from one part of the world to another, whether for the purpose of effecting a temporary or a permanent change of base. It was extreme mobility which enabled the British battle-cruisers to take the German squadron by surprise at the Falkland Islands.

An increase in size, on the other hand, necessitates larger principal dimensions, which limit the strategic utility of ships by debarring them from access to channels, canals, ports and docks that would be open to smaller ships. This consideration, in fact, always imposes a limit on the size of battleships; but since channels and harbours may be deepened, and docks as well as canal locks may be enlarged, this limitation is in general temporary, being of a financial nature and depending in most cases on the ability and willingness of a country to carry the expenditure required for the execution of such works. It must, however, be borne in mind that in some cases the works may be of such magnitude and cost that a long time must pass before they can be carried out. Such a case is that of the Panama Canal, the locks of which are likely to impose a limit on the beam of battleships of certain navies in a not distant future. This is the more serious, because submarine dangers may render it desirable to adopt a much larger beam than hitherto customary, quite apart from the increase in beam naturally following from larger size of vessel.

The superior speed, combined with greater compactness and handiness, of a fleet of large and fast battleships, as compared with a more numerous fleet of smaller vessels of slower speed, confers upon the former the important advantage of greater facility of tactical concentration, whatever form this may take. The less extensive line of the larger vessels possesses the further advantage of greater density of gunfire, which, if brought to bear on individual ships or limited sections of the enemy's forces, cannot fail to have an annihilating effect (Blücher). In fact, the intensity of fire will be proportional to the square of the artilleristic superiority at the point of contact. The commander of the faster fleet, moreover, is able to control the course of the battle, since he has it in his power to join action at the time and under the conditions most favourable to himself. The tactical advantages gained by the larger ships in virtue of higher speed will be enhanced, under proper conditions of navigation, if the guns are of superior range and power; in other words, if the larger ships are in possession of the speed-armament gauge, which renders them capable of using their battery at ranges where the weaker ships are unable to reply effectively.

While strategical and tactical considerations on the whole favour an increase in displacement, they, on the other hand, impose a limit to the evolution in that direction on account of the claim to divisibility of the forces. Strategic conditions often demand a division of the fleet into a certain number of minor fleets or squadrons, and tactical reasons as well as the necessity of providing for absences and losses determine a minimum value of the number of units in each squadron. Thus the least total number of ships is given, but since the aggregate battleship tonnage is fixed at a certain maximum by the financial resources of the country, there must at any given time be a limit to the displacement of each ship. In most of the smaller navies this limit has been reached or even passed. In some cases where the total tonnage is distributed on four, six or eight units, as considered necessary to constitute a squadron, the ships are individually too small and too weak for the intended service, due to financial restrictions. In other navies, where it has been preferred not to restrict the size, the number of ships is reduced to two, which is too small to provide for absences and losses. In the British Navy the limit imposed by the claim to divisibility is not reached, and, in view of the wealth of the country, it does not need to be considered at the present time.

Size in Relation to the Risks of Accidents and Losses.

Every ship, however large, is exposed to certain dangers of navigation, of which the most important are those due to grounding and collision, which may result in temporary disability or total loss. All ships, moreover, are liable in the ordinary course of the service to be put out of commission by breakdowns in the machinery and appliances, necessitating shorter or longer visits to ports where repairs can be carried out. In time of war there is to be considered in addition the dangers incidental to attack by artillery, torpedoes and mines, as well as increased liability to breakdowns due to the more intense service. The larger the ships and the smaller their number, the more serious is the loss or disablement of each unit. It is necessary, therefore, to examine whether it is wise, in view of the attendant concentration of risk, further to increase the size and value of individual battleships.

In considering the dangers of navigation and the chances of breakdowns of the *matériel*, let us first assume that they are the same for large ships as for small. Now, since the probability of such mishaps must increase in direct proportion to the number of units, and since this number for a given total tonnage is inversely proportional to the displacement of individual ships, the percentage of absences or losses in a fleet, measured in tonnage, must be the same whether the ships are large or small. If, in a fleet of eight ships, one ship is liable to be disabled during a certain period of time, it is probable that two out of a fleet of sixteen smaller ships of half the size would be disabled in the same period. The percentage loss would be the same in either case.

It may be argued that larger vessels are more liable to run aground than smaller vessels on account of their greater draught, and that they are more exposed to collisions due to the inferior manœuvring qualities; but these drawbacks are probably more than offset by the fact that larger vessels can be better equipped for navigation both as regards *personnel* and *matériel* and, as explained above, they can be more minutely subdivided. The *matériel* can be better safeguarded against accidents or breakdowns. On the whole, then, we conclude that the risks incidental to service under ordinary conditions of navigation are not enhanced by going to larger displacements.

As regards war risks, the intensity of attack by artillery and torpedoes, to which battleships are exposed, will be in a broad sense directly proportional to their size, because, again, the number of units is reduced in the same ratio as the displacement is increased. Larger ships, therefore, will be more liable to damage and destruction than smaller, unless the means of protection and defence can be developed and strengthened in the same measure as the intensity of attack is increased, but this, in fact, appears to be quite feasible. The degree of protection that can be obtained by passive means, such as armour, subdivision, under-water bulkheads of special construction, nets, and other appliances, is fairly proportional to the displacement. The active means of defence, whether carried by the ship itself, such as guns and torpedoes, or extraneous, such as patrol vessels and aircraft, can be likewise rendered proportionately more effective in a fleet consisting of a smaller number of larger vessels than in a more numerous and more scattered fleet of smaller vessels.

Mine attack, being of a passive nature, is in this connection analogous to the dangers of navigation, under which large and small vessels are exposed to practically the same risks.

Conclusions.

It is evident that if the claims advanced above are to be fulfilled, battleships must be at least as large and probably larger than any existing vessels of this class, and "small" battleships are thus at once ruled out. The discussion shows, moreover, that larger ships, quite apart from their greater carrying capacity, possess inherent nautical, technical, military and economic advantages which render them intrinsically superior to smaller. These advantages cannot be obtained by an aggregation of smaller vessels, however great their number.

It is shown also that the risks of war and peace are no greater for large than for small ships. The limitation to an increase in size imposed by the requirements as to tactical and strategical divisibility of the forces is essentially a financial one and need not, so far, be considered by any great and wealthy nation. The only active limitations are those due to restrictions in the use of ports, docks, canals and channels. These limitations, although of a yielding nature, inevitably accompany increases in the principal dimensions and can never be entirely ignored.

Taking all arguments into consideration, it appears that a smaller number of larger battleships are from almost every point of view preferable to a greater number of smaller vessels, but it seems wise not to exceed the displacement strictly necessary to secure the desired nautical and military qualities, so as to minimise, as far as possible, the effects of the above-mentioned hydrographic restrictions.

Battleships have always required the assistance of lighter vessels for scouting, despatch service, and other strategic duties, but tactically they have up till quite recently been self-contained units. It is of interest to note that under modern conditions of warfare this is no longer the case. Battleships and battle-cruisers now require for their assistance and protection in battle a variety of attendant ships of different types, the most important of which are light cruisers, destroyers, submarines and aircraft. This specialisation renders it possible to make each type more perfect of its kind and justifies the enormous concentration of power in the large artillery ship, which, whether it is acting singly or in squadron, becomes the nucleus of a complex unit where every fighting quality, offensive and defensive, is represented at its maximum value.

Norwegian Schooners.—The construction of six auxiliary schooners for Norwegian interests, involving 1,500,000 dols., is to be undertaken by the Heath Shipbuilding Company, Portland, Oregon. A site has been selected in South Portland, adjoining the yard of the Portland Shipbuilding Company. The vessels are to be of the top-mast type, 266 ft. long, with 45 ft. beam. Their deadweight capacity will be 3,000 tons; three will have twin oil-burning engines of 240 h.p., and the other three engines of 385 h.p., all of the Skandia type.

Continuous Pulp-Drying Machinery.—The automatic rational drying appliances, a revolving table and a pump, made by the firm of R. W. Dinnendahl, of Essen, and briefly described in the *Chemiker Zeitung* of October 14, 1916, may not be quite so novel and continuous as claimed, but they seem to deserve notice. The first machine is a table covered with filter cloth which is radially divided into a small number of cells. Over the cells fits a filter frame, and underneath the cloth are the vacuum pumps; the table revolves slowly. A uniform layer of the pulp, &c., to be dried is continuously spread on the cloth of a cell by means of a hopper; as the table turns slowly the pump is cut out, and the dried pulp is removed, if necessary with the aid of compressed air. An arrangement for cleaning the filter frame is inserted between the removal zone and the feed zone. This table is recommended for drying chemical and other products containing up to 75 per cent. of water. The second machine is essentially a piston pump, the barrel axis of which is inclined so that the end is at a higher level than the front. The cover at the end is adjustable in position, and the pressure to which the material is to be subjected can thus be varied. The barrel is continued in a tubular extension, made of some material which allows the water to escape. The pump is recommended for pulps containing 90 per cent. of water. The wet material is fed into the barrel through a hopper during the return stroke of the piston. On the forward stroke the material is compressed and the water forced out, and the compression increases until the dried pulp is squeezed out through the end of a tube. One of these machines is said to have dealt successfully for several years with a material containing 92 per cent. of water.

THE ARRANGEMENT OF MACHINE SHOPS.—No. IX.

By JOSEPH HORNER.

THE Auto Machinery Company, Limited, of Coventry, manufacture both ball and roller journal bearings in a large range, and for light, medium and heavy duty. The illustrations, Figs. 64 and 65, show a typical ball journal bearing in its housing. Other illustrations on pages 634 and 635 show the location of the machine tools in the firm's new tool room, the arrangement of the line and countershafts, and various details of the methods employed for supporting the motors, hangers, &c.

The design of the ball bearings, which is shown embodied in a 2½-in. line shaft bearing in Fig. 64, may have the following features noted. The balls are retained in a cage which is formed of two portions riveted together between the balls. The inner races are made either a press fit on the shafts or, as in the illustration, they fit over a tapered sleeve that is tightened with a circular nut. The outer races are a sliding fit in the housing, with a slight lateral clearance allowed on the inner sides when two bearings are used in conjunction. A slight movement is thus permissible to allow the bearing to assume its correct position. The bearing is rendered dirt proof by means of caps which are screwed against the ends of the housing, with inner grooves. Another method adopted is to insert a felt washer in a recess in each cap, around which a spring ring is placed to maintain pressure on the felt as the latter wears.

When end thrust has to be provided for, ball thrust bearings with either a single row or a double row of balls are fitted. The latter are used when the load comes alternately in opposite directions, or when it is of an intermittent character. Instead, two single thrust bearings may be employed. The single ball thrust bearings which take thrusts in one direction only comprise two hardened steel plates between which a row of balls runs in a retaining cage of gunmetal. The plates have shallow concave races. One is made to fit the shaft, the other has a clearance hole, but is made a fit in its housing, while the first has clearance in the housing. The double ball thrust bearings have the central plate a free fit over the shaft, but it makes tight contact in an external housing. The outer plates fit the shaft tightly, being located by a shoulder and adjusting nuts.

All these bearings are ground to very fine limits. All races which fit the shaft are true within a limit of 0.00025 in. either above or below the nominal bore. Externally, bearings up to 5-in. diameter are guaranteed true within a limit of 0.0001 in. above and 0.0003 in. below the nominal diameter. Bearings above 5-in. external diameter are accurate within a limit of 0.0001 in. above, and 0.0004 in. below the nominal diameter.

The firm's roller bearings, used for heavy machinery, comprise inner and outer races, and rollers retained in a cage, which consists of two end rings recessed to receive the rollers, and riveted together. The inner race is grooved to receive the rollers, the outer race is plain.

Fig. 66, on page 634, is a plan view of the tool room of the Auto Machinery Company, Limited. It is a large and important one. The lay-out of its shafting and motors is shown by Fig. 69, page 635, which also includes the heating pipes. Each length of shafting is driven by its own motor of 20-h.p., whence the countershafts are belted to their several machines. The motors, making 965 r.p.m., drive the line shafts through chain reduction gears of 16 teeth to 106 teeth on the shafts. The shops are covered with a sawtooth roof of timber, Figs. 70 and 71, and the hangers which carry the line-shaft bearings are bolted up to the horizontal roof beams (compare with the details, Figs. 67 and 68, which illustrate an alternative method of driving in which the line shafts are belted from the motors instead of being driven through chains, as in Fig. 69). In Figs. 70 and 71 the method of securing and adjusting the motors is shown. Channels are laid back to back with cast-iron packing between. They carry timber blockings, to which slide rails are bolted with clips embracing flanges on the rails. The motor is adjusted along these rails by screws at the end to tighten the driving chain. Three locations for the motors are shown in the plan view, Fig. 71, and the motor slide rails are seen in detail in Figs. 72 and 73.

The method of attaching and securing the channels to the horizontal beams is illustrated in the detail, Figs. 74 and 75. Washer plates above embrace the flanges, and fit between the channels with a tongue. Two bolts pass through each plate down the sides of the beams through a washer plate below. Distance pieces are inserted at intervals between the backs of the channels, and are secured with a bolt. The fixture is thus immovably secured to the roof beam.

The method by which the hangers are attached to the underside of the beams is seen in the detail, Figs. 76 and 77. Here the foot of the hanger embraces the beam, and bolts pass up by the sides and go through a washer plate on the upper face.

This is a highly interesting example of an extensive and very completely equipped tool room which has to serve a large factory devoted to an exclusive manufacture, that of ball and roller bearings, and automatic machine products—screws, pins, and allied manufactures. A large number of tools and jigs are required to feed a big and highly specialised factory. A small smithy is included, seen in Figs. 66 and 68, page 634, with one forge and anvil, water tanks, swage block and vice bench. The smithy has a motor-driven fan for the hearth, and a blower for a muffle furnace and a blowpipe. The boiler for the heating apparatus is located at the narrow end of the smithy. The disposition of the pipe-lines is indicated in Fig. 66.

Adjoining the smithy, and between it and the tool room, is the jig and store room on the ground floor. At the opposite or left-hand end of the tool room a large area is occupied by fitters' benches, with two marking-off tables. Adjacent are two hacksaws for bar stock. The machines in the tool room are arranged in parallel lines with wide gangways between, their exact locations being fixed by their countershaft pulleys. A comparison of the two plans, Figs. 66 and 69, will show clearly the relative positions of the machines installed and the driving shafting.

Considerable modifications have been made in this shop, now no longer used as a tool room, but being occupied in the manufacture of 18-pounder shells, and the light parts of motor engines for aeroplanes, &c. The lay-out, however, remains the same, except that some rearrangements of machines and their countershafts have been made.

The illustrations of shops which have been shown in this and in preceding articles reveal the permanence of belt-driving. None of these shops are survivals from an earlier date. They have all been of recent design and lay-out, and, therefore, we must accept them as a tribute to the general preference given to driving by belts instead of by individual motors. Even the small group system of motor-driving has been but slightly represented. In most of these examples one motor has driven one long length of line shafting, whence the countershafts are driven as of old. The difference lies in the substitution of the motor for the steam engine. There must be something more than mere conservatism of practice behind the retention of the long-line shaft and belting. Perhaps the reasons—for there appear to be several—are not very obscure. And the question may be of some interest why, when individual electric driving has been advocated strongly, and has been available for several years, and in use in some shops, that it is not being commonly adopted.

The reasons are probably the higher outlay which is required for individual motor equipment over that of belts, and which would total to a large amount when large numbers of machines are laid down. Next, the greater frequency and cost of repairs. Finally, the fact that belts receive more careful and intelligent attention and treatment than they formerly did, and therefore return better results. A collateral fact is that shafting, pulleys and belting comprise an inseparable unit. Much of the blame that has been hitherto cast on the belting must be shared in equal or larger proportion by the shafts, the shaft bearings and the pulleys, each of which has been wasteful and unsatisfactory in the very recent past. These have been highly improved in all those details which make for total efficiency, and with them the belt service has been rendered more satisfactory. So that the contrast is not now that between individual motor driving and an antiquated system of belt driving, but with that of more efficient methods and much improved details. Casually, the belt drives bear the same aspect as of old, but the resemblance is only superficial.

The higher outlay that is entailed by the fitting of individual motors to small machines over a belt system is practically prohibitive. To be successful, not only must their cost be reduced, but machines must be built more generally to receive their motors as integral elements, and not to entail a belt drive from motor to machine. A goodly number are constructed for either alternative, and the practice may be expected to increase. But, even so, the higher cost would appear to more than outweigh advantages which might follow the dispensing with belts in the driving of the smaller machines, and of those of medium dimensions.

Exact speed regulation and uniform speed are facts urged in favour of the all-electric drive for machine tools. But these have been secured by the installation of large motors driving lengths of shafting, by more rational methods of belt transmission, and finally, and most extensively, by the substitution of geared speeds and feed regulations for the older belt cone drives. These geared drives are positive, exact, quick in action. Belt changes fulfil neither condition. The gears supply speeds and feeds in small increments and by regular gradation, which belt cones and back gears hardly ever did, and, as is now a familiar fact, they frequently derive their movements from a single pulley, belt-driven, the analogue of the one first-motion shaft coupled to a motor, or belt driven from it.

The frequency and cost of repairs to motors are not negligible considerations. Injuries to motors cannot be dealt with so readily as can the little attentions which belting requires. A belt can be taken up and refastened in a breakfast or dinner hour. A motor may have to be dismantled for a day or two, with the result that its machine is put out of service for the time being.

But the present very live problem of all—line-shaft *versus* individual electric driving—is one which cannot be solved satisfactorily in the same way for all shops. Although the first cost of

Fig. 64.

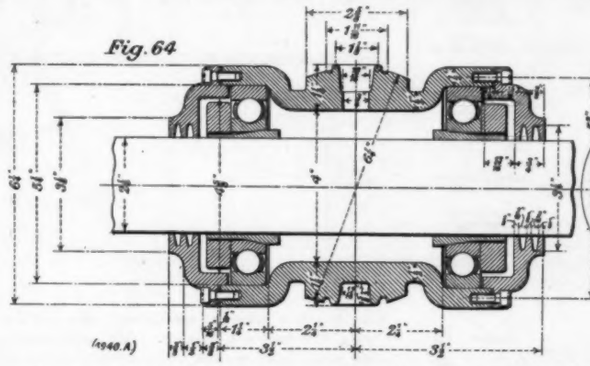
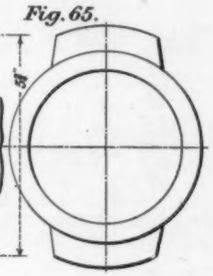
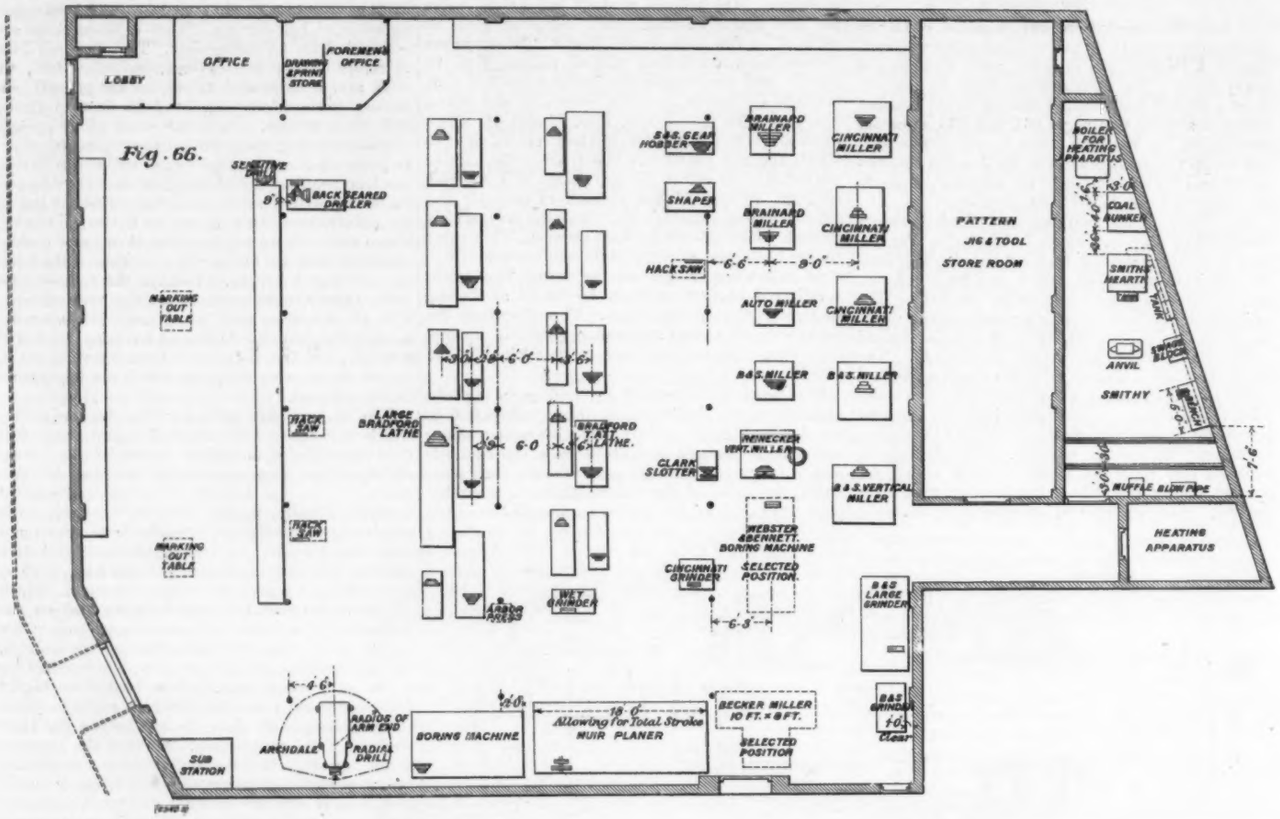


Fig. 65.

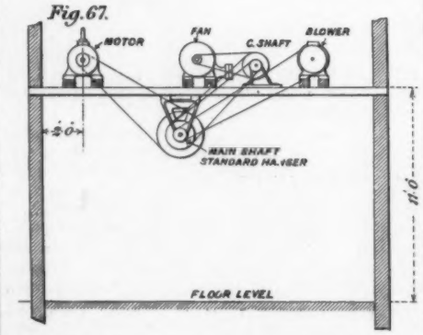


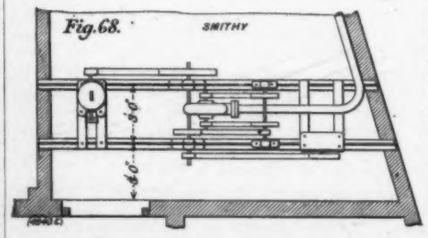
TOOL ROOM OF THE AUTO MACHINERY COMPANY, LIMITED, COVENTRY.



individual motors is higher than that of shaft and belt driving, this states only one aspect of the problem. As already remarked, the decision in favour of motor driving is never doubtful in the case of large and heavy machines. It is when the smaller machines are concerned that differences of opinion occur. Some of the principal conditions may be stated.

The spacing of machines is one of the prime factors in the problem. At extremes we see machines scattered sparsely over a large shop area, and machines crowded as closely as they can be, to leave room for the attendants and the handling of the work. Again, both conditions are often present in one floor area, at one end of the shop the first arrangements exist, at the other end the second; and, further, adjacent machines may be all alike in class and dimensions, or they may be dissimilar in both respects. And, again, these arrangements may be of a temporary character, as in newly-built and in rapidly-extending shops, and in shops where capital outlay has to proceed in stages and by instalments, or they may be of a reasonably permanent character. Large open spaces may be necessary in order to leave room for the handling of massive work, as in departments of marine and heavy stationary engine work. Fitting and erecting are frequently carried on in the machine-shop areas among the machines, adjacent to the machines where the later stages of tooling are being done, and also in proximity to the large floor plates where portable tools are employed. Again, there are testing and inspection benches, tool rooms and stores, hardening shops and stock racks, which often break the continuity of the machine arrangements. On the other hand, groups of similar machines, automatics, light lathes, gear-cutters, small drills, small grinders, occur in considerable numbers in groups adjacent, constituting departments which for practical purposes are self-contained, shops performing repetitive work of one kind under the charge of a separate foreman or chargeman. And these conditions differ very





widely in another point of view from those which control the operations of some of the other kinds of machines, the heavier ones particularly. Many of these suffer from long enforced periods of idleness when heavy and awkwardly-shaped pieces of work have to be set up for tooling without help from fixtures, lined-out pieces set with packings and clamps. Machines, too, are sometimes idle for considerable periods while waiting for work. And in some classes, planing machines most notably, and in some of the boiler-shop machines, as those for shearing and punching, the amount of power absorbed is extremely irregular. In the planers more power is taken at the instant of reversal than during the heaviest cutting. All these considerations must have weight when attempting to make a choice between line-shaft and belt driving and individual motor driving.

The case of large heavy machines is of a wholly different character, and therefore these are being built in increasing numbers with all-motor drives. The explanation and justification lies in the large size of belts required for these, with the labour of belt shifting, and the heavy slides, carriages and gears to be moved, for which individual motors are preferable. The fact that the outlay on these motors is less relatively to the outlay on the machine itself than is the cost of a motor to drive a small machine amply justifies the increasing practice of abandoning belt driving in favour of that of individual motors in nearly all the newly-built massive machine tools.

When machines of massive or of average dimensions are scattered sparsely about a shop, the extension of line shafting to cover them all does not seem so suitable as the individual motor drive. The cost, the friction, and the idle periods of some of the machines are a set-off against the higher outlay on motors. And when machines have several movements, involving heavy weights, again the motors have the advantage. The planing machines with a high peak load at reversal are served better with motors. When small machines of one class are grouped, a line shaft serving the whole, and motor-driven, should have preference.

The foregoing are comparisons of a positive character concerned with the direct relation of the suitability of the driving agents and the machines. But there are other subsidiary and incidental matters which must carry weight in the endeavour to arrive at a wise decision. There is first the familiar fact often adduced that shafting must be running if only one or two machines are in use, as happens sometimes in working overtime on a push repair job, while, using individual motors, no loss occurs, since only the motors driving machines that

TOOL ROOM OF THE AUTO MACHINERY COMPANY, LIMITED, COVENTRY.

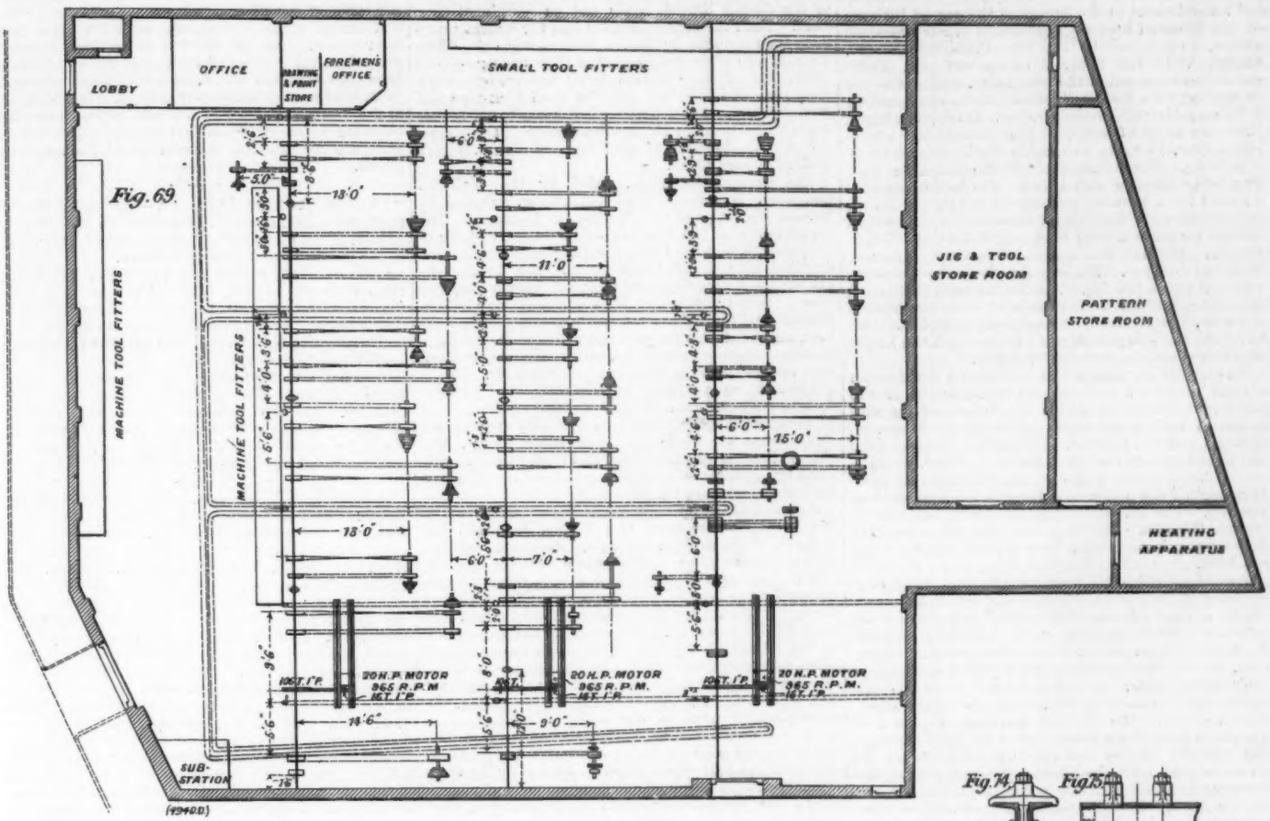


Fig. 69.

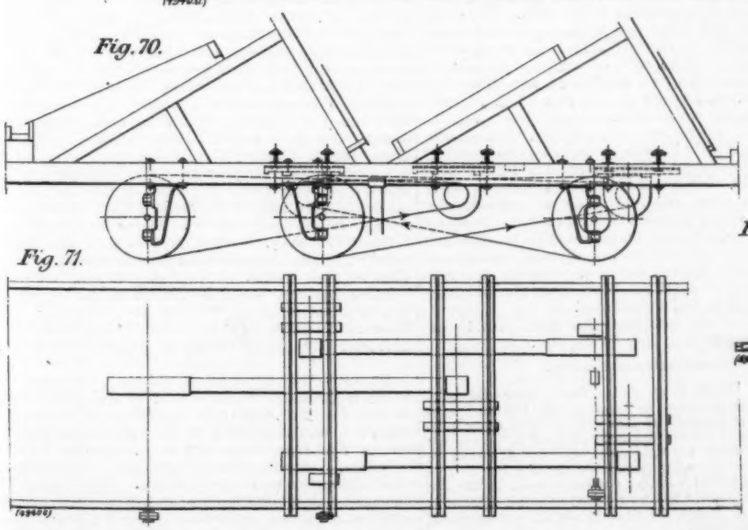


Fig. 70.

Fig. 71.

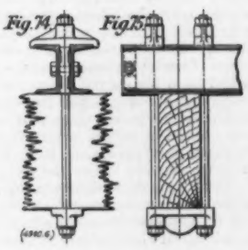


Fig. 74. Fig. 75.

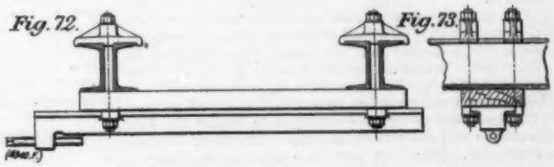


Fig. 72. Fig. 73.

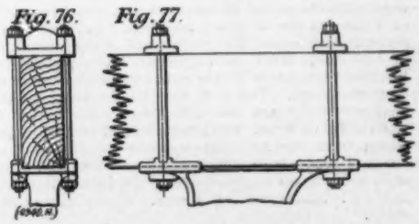
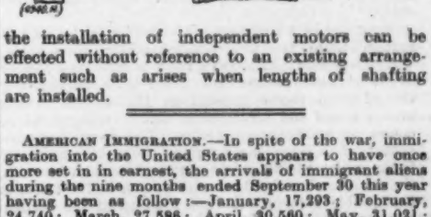


Fig. 76. Fig. 77.



are actually running are using power. But another aspect of the subject relates to the obstruction which large forests of belting offer to the diffusion of light about a shop. This is especially noticeable on dull days and in artificial lighting when arc lamps are located high above the belts that drive from line to countershafts. In some cases, too, the belt arrangements would clash with the movements of overhead travelling cranes and of swinging jib cranes. The increase in the height of shop buildings and the general abandonment of floors and side galleries in new shops have increased some of the objections to belt driving. Belt placing and shifting was accomplished more easily when the shafting was low and a short ladder only wanted. Now mechanical belt shifters are often substituted. So here, as in other matters, the threatening innovations of the electrician have been anticipated, and improved methods adopted by the quickened ingenuities of the machine-tool builders and the manufacturers of power transmissions.

Although the first cost of motors is higher than that of installations of shafting, yet suitable girders must be provided in the building for line shafts, beams for countershafts, brackets, hangers, and so on. To employ the best roller bearings, the best pulleys, lubricators, couplings and so on, entails a much higher outlay than the old-time shafting involved, which ever gets appreciably nearer to that of motor installations. And although the efficiency losses in small motors are high, higher than they are in large ones, yet they are much below those which occur in belt-driven installations. And since extensions to works are so frequently necessary, the installation of independent motors can be effected without reference to an existing arrangement such as arises when lengths of shafting are installed.

AMERICAN IMMIGRATION.—In spite of the war, immigration into the United States appears to have once more set in in earnest, the arrivals of immigrant aliens during the nine months ended September 30 this year having been as follow:—January, 17,293; February, 24,740; March, 27,586; April, 30,560; May, 31,021; June, 30,764; July, 25,035; August, 29,975; and September, 36,398. These figures show an aggregate of 253,372 immigrant arrivals in the first nine months of the current year, as compared with 189,782 in the corresponding period of 1915.

SINGLE-SCREW GEARED TURBINE INSTALLATION FOR A CARGO SHIP.

(*Concluded from page* 581.)

In supplement to the details of the geared turbines of the Ellerman liner City of Canton in our preceding article, we give on the two-page Plate No. XLIX., accompanying this issue, elevation and plan of the general arrangement of the machinery, which is no less interesting than the details of the turbines and gearing.

We may deal first with the boilers. As shown in Fig. 6, there are three of these, of the multitubular single-ended type, 16 ft. 4½ in. outside diameter and 12 ft. 7 in. long. The furnaces are of the Deighton type, four being fitted in each boiler. The boilers are constructed for a working pressure of 190 lb. per sq. in. Superheaters are fitted to all three boilers, the special fittings for these having been supplied by the North-Eastern Marine Engineering Company, Limited, Wallsend-on-Tyne. The amount of superheat contemplated is about 125 deg. F. at the turbines. Diamond blowers are fitted to the back of each combustion chamber, with steam connections complete. One large elliptical-shaped chimney is provided, the height of which above the grate is about 90 ft.

The boilers are designed to work under the Howden system of forced draught, the construction of the parts involved being carried out in accordance with drawings and instructions provided by Messrs. J. Howden and Co., Limited, of Glasgow. For supplying air to the system one large fan is provided, which is driven direct by one single-cylinder double-acting open-type engine, the piston rods being fitted with metallic packing. The fan and engine have been supplied by Messrs. Howden. The disposal of the ashes from the boiler room is dealt with by a double cylinder steam ash hoist.

Special attention has been given to the arrangement of pipes and valves for the main and emergency steam supply to the turbines. The shut-off and manœuvring valves are placed near the engine room forward bulkhead and high up, on a level with the boiler stop valves. (Fig. 5.) By this means no other pipe connection, in the engine room, to the turbines, than the one immediately in use is filled with the highly superheated steam. The starting platform is placed at about the level of the centre line of the main turbines, the spindles of the manœuvring valves being led down to this, with the wheels, pressure gauges, and counters grouped about a pedestal placed adjacent to the engine room forward bulkhead. The valve spindles are further extended and arranged also to be worked from the engine room lower platform or floor in case of emergency. The fact that steam from the boilers may be passed direct to either high or low pressure ahead or astern turbine has already been explained in our previous article, so that either turbine unit can independently drive the ship through the gearing. The thrust shaft, shown in Figs. 5 and 6, and the main line shafting and propeller shaft, are of forged ingot steel. The propeller is of the built-up type, with boss of cast iron, and having four blades of manganese bronze.

In our previous article we dealt with the condensing plant. The feed water is passed through a filter or cleanser of the "Cascade" type, supplied by the Contraflo Condenser and Kinetic Air Pump Company, Limited. The filter tank is provided with the necessary float gear for controlling the feed pumps. The main air pumps are arranged to deliver the feed water to this filter tank and the feed pumps to draw therefrom. The feed pumps consist of one pair of direct-acting vertical pumps, each pump being capable of delivering the necessary feed water under ordinary service conditions. The water ends of the pumps are of cast iron, fitted with gunmetal liners, gunmetal buckets, manganese bronze rods and bronze valves in gunmetal seats. The feed water is delivered by the feed pumps through one surface feed-water heater of the multiflow type, which is arranged to utilise the steam from the auxiliary machinery. The shell of the feed heater is of close-grained cast iron and fitted with solid-drawn copper tubes. The feed pumps and the feed heater are of Messrs. Weir's well-known make.

Arranged in connection with the forced lubrication system there are two single-cylinder direct-acting vertical pumps which have been supplied by Messrs. Weir. These pumps are fitted with suctions to the oil drain tanks situated in the double bottom of the vessel and arranged to deliver through an oil cooler of multitubular design. The connections are such that delivery can be made either to gravitation tanks or direct to the gearing and turbine shaft bearings, the oil after use finally draining back to the tanks in the double bottom. A duplex pump of the vertical type, supplied by Messrs. Lamont and Co., is fitted for providing circulating water to the oil cooler.

Other auxiliary machinery forming part of the complete engine room installation includes a service donkey for general purposes. It is of the vertical duplex type, and is also arranged to deliver to deck for sanitary purposes. A large ballast pump of the vertical duplex type is fitted for dealing with the water ballast carried in the double bottom tanks and an additional deep tank. Both the service donkey and the ballast pump have been supplied by Messrs. Lamont and Co. There are also two bilge pumps worked from the gear-wheel shaft, one of these pumps being arranged to draw from the sea and deliver into the wash deck pipe and sanitary tank. For delivering feed water to the boilers when in harbour an independent pump of the single-cylinder direct-acting vertical type, of Messrs. Weir's make, has been fitted.

The evaporating plant, fitted by the Wallsend Company, consists of one evaporator, supplied by Messrs. Hocking and Co., Limited, of Liverpool. The evaporator is of the merchant-service type, capable of evaporating 30 tons of water per day of 24 hours when supplied with direct boiler steam. For feeding the evaporator a vertical pump of the simplex low-service type is fitted; this has been supplied by Messrs. Lamont and Co. The auxiliary pumps generally have been made suitable for working with steam, having a moderate degree of superheat, and to this end are fitted with metallic packing to the steam piston rods.

There is an auxiliary condenser of the ordinary design, with cast-iron body of circular section. It is of sufficient capacity readily to deal with the exhaust steam from the whole of the auxiliary pumps, &c., electric lighting plant, winches and deck fittings. The auxiliary condenser is of the non-vacuum type and arranged to drain to the filter tank.

As much of the heat generated in the boilers can be lost to the atmosphere by radiation from the hot surfaces of the boilers, turbines, pipes and fittings, auxiliary engines, &c., resulting in a wasteful expenditure of fuel, special attention has been given to this matter by the marine superintendent of the Ellerman Lines, Mr. Alexander Dalrymple, who supervised the work for his company. The result of the application of the lessons of this experience is an elaborate and effective arrangement of lagging being provided for all exposed hot parts, which must tend to increase the economy. In the case of turbine casing, the inner cleading next to the walls of the turbines is 3½ in. thick and consists of magnesia composition 1 in. thick covered with 2½ in. of diatomite composition; there is next an air space, which is enclosed by the outer cleading material, consisting of magnesia blocks 1½ in. thick, the whole being cased with planished steel sheets secured with polished steel bands. The edges of all flanges and every part from which heat might radiate are carefully covered with either composition or mattresses. In the case of auxiliary machinery, all steam cylinders of all auxiliaries, excepting only the ash hoist, are covered as follows: 1½ in. of magnesia or similar composition placed direct on the castings from where heat may radiate, then an air-space, enclosed by 1½ in. of asbestos mats, all covered by planished sheet steel. The covers are lagged with asbestos mats, over which is placed a portable cover of planished sheet steel. The above methods also apply to the feed heater and evaporator. Similarly effective methods, having due regard to the temperature of the parts, are also employed for all steam and exhaust pipes, with their fittings, the main condenser, the low-pressure turbine eduction pipe and the auxiliary condenser, boilers and smokeboxes.

The whole of the machinery has been built to the rules and regulations of Lloyd's Register.

American Blast-Furnaces.—There were 326 coke and anthracite furnaces in blast in the United States at the commencement of November. The daily productive capacity of the furnaces in blast in November was 108,622 tons, as compared with 106,578 tons in October. The aggregate production to October 31 this year was 32,549,894 tons, as compared with 23,431,936 tons in 1915; 20,015,384 tons in 1914; 26,507,371 tons in 1913; and 23,969,899 tons in 1912 (corresponding periods in each year).

Hot Water by Solar Heat.—Half the inhabitants of Monrovia, California, and many inhabitants of other settlements near the Pacific Coast are said to rely on the sun for heating their bath water, &c. The descriptive note in the *Scientific American* of August 12 is not very explicit. A shallow box, about 4 in. deep, is placed on the roof of the house or some suitable stand. The bottom of the box is made of copper, the cover is glass. On the bottom rests the copper coil through which the water circulates to and fro, the one end of the coil being connected to the water main below, the other to the hot water tank. As the water gets warm—nearly boiling, it is stated—it rises and flows from the coil into the tank, cold water being automatically replenished from below. The tank and box are well guarded against heat losses by radiation; thus it is said to be possible to draw hot water even in the early morning or after a cloudy sunless day. There is no mention of further particulars; the pipes might be coated with lamp-black or painted to become good absorbers, one should think.

YEAR-BOOKS AND ANNUALS.

The Potsdam Diary.—This diary, which is compiled by Mr. L. J. Maxse, the editor of the *National Review*, measures 3¾ by 2¾ in., has one page for every day, and several pages for memoranda and general postal information. As in the former editions, there are printed at the bottom of each page a few lines taken from the speeches delivered at different times by prominent men of many nationalities. It is dedicated to the "British Potsdam Party who, in Peace and War, play the game of Britain's enemies." The extracts given clearly illustrate German perfidy, among other points.

The Post Office London Directory.—The edition for 1917, the 118th annual issue of this well-known book, has now appeared, thus keeping up the regularity which ruled in the publication of pre-war editions. It is published by Messrs. Kelly's Directories, Limited, 182 to 184, High Holborn, London, W.C., at the price, including the county suburbs, of 45*s.* in one volume, and 50*s.* in two volumes. It can also be obtained in the provinces, in Paris and in New York. The Directory requires no special comment—it is, so to speak, on every desk in London and throughout the Empire, and always forms a welcome guide to every business man, in any capacity. In the present volume the displayed advertisements have increased in number, a proof that the value placed upon the book as an advertisement medium is fully maintained.

Almanacks and Calendars.—We have received from Messrs. Cammell, Laird and Co., Limited, an illustrated almanack, two months on a page, each one of the six pages giving a three-coloured picture of steamers and views in Messrs. Cammell's works. Messrs. John Thornycroft and Co., Limited, have also sent us a copy of their neat almanack, showing a British warship, the flyleaf for each month illustrating their other specialities. Messrs. Abdulla and Co., Limited, have issued, like last year, a most artistic almanack depicting scenes in the great war. Other almanacks have reached us from Messrs. Peckett and Sons, Limited, the well-known locomotive builders, of Bristol; from Messrs. J. C. Fish, Hall and Co., printers, 11, Bishop's-court, Chancery-lane, W.C.; and from the Pennsylvania Railroad system. The Sun Electric Company, Limited, 118 and 120, Charing Cross-road, W.C., have issued their Sun Desk Calendar, fitted to an artistic metallic base; it has a leaf for each day in the year, with space for memoranda. The calendar sent by Messrs. Clayton, Son and Co., Limited, the gasholder and gas plant manufacturers, Hunslet, Leeds, has a flyleaf per month from January, 1917, down to December, 1920, inclusive. The Anglo-Mexican Petroleum Products Company, Limited, Finsbury Court, Finsbury Pavement, E.C., have issued an almanack illustrating their refinery and depôts. The daily tear-off almanack issued by Messrs. Henry Simon, Limited, Manchester, in the usual form, is as interesting this year as it has been for a large number of years past. For each day in the year a maxim is given taken from the writings of British and foreign writers and thinkers. The Kennicott Water Softener Company, Wolverhampton, have also issued a daily tear-off almanack, showing a number of applications of their plants. A very elegant desk monthly calendar has been issued by Messrs. Edgar Allen and Co., Limited, Imperial Steel Works, Sheffield; and Messrs. John Smith and Co., Grove Works, Carshalton, have sent us their usual cardboard calendar for the year.

Diaries.—The Syren and Shipping, 91 and 93 Leadenhall-street, E.C., have sent us a copy, the first edition for 1917, of their International Mercantile Diary; it measures about 10 by 8 in., and the diary section has three days per page. Besides various calendars, it contains a large amount of mathematical data, conversion tables and formulæ; also commercial information on the British Empire and on every country of the world, except in the case of enemy countries and countries in the occupation of enemy forces, on which no information is given pending the return of peace. The diary is issued at the price of 5*s.* net. Its object is to facilitate the development of trade between Great Britain and foreign countries, and this object it will certainly attain.—Messrs. Cammell, Laird and Co., Limited, Birkenhead and Sheffield, issue a diary with two pages for each week, much general and engineering data, and several perforated section-marked pages for memoranda.—Messrs. J. Stone and Co., Deptford, send one with a page for each month, cash account pages, and "things one wants to know," the remainder of the book being made up of ruled pages for notes, &c.

The late Mr. Arthur James Ireland.—We regret to have to record the death, which occurred on the 22nd inst., of Mr. Arthur James Ireland, who for many years was associated with the British Thomson-Houston Company, Rugby. Mr. Ireland was 57 years of age.

THE PRACHE AND BOUILLON EVAPORATING PLANTS.

THE most simple type of steam-heated evaporating or distilling plant generally used may be regarded as practically a form of tubular boiler, in which the tubes are traversed by the heating steam, the liquid to be evaporated being contained in the surrounding vessel, or in which—for certain reasons—these positions of the liquid and heating steam are reversed. Whatever be the system followed, when the liquid, previously heated to boiling-point, is introduced in the apparatus, there will be for each lb. of steam used for heating about 1 lb. evaporated from the liquid, giving rise to 1 lb. of steam at a pressure below that of the heating steam. In other words, there is evacuated a weight of steam nearly equal to the weight of the heating steam used, but having a less pressure than the latter. Such an apparatus forms a single-effect evaporator.

The rapidity with which the heating steam condenses, and hence the rate of evaporation of the liquid under treatment, depends upon the difference in temperature which exists between the heating steam and the liquid. Owing to the high rate of transmission to the metal of the apparatus of the heat contained in the heating steam, the evaporative power of the apparatus per unit of surface is considerably higher than that which obtains in coal-fired steam boilers. In fact, with a temperature difference of about 10 deg. C. between the heating steam and the liquid, as high a rate of evaporation is obtained as with coal-fired steam boilers.

In order to reduce the steam consumption in the single-effect apparatus referred to above, two methods are available.

Multiple-effect Process.—If we consider a single-effect evaporator in which ebullition takes place at atmospheric pressure, and if the steam produced in this be used for heating a similar apparatus, in the ebullition chamber of which a certain vacuum be maintained by leading the steam therein produced to a condenser, then the steam for heating the first apparatus will produce in each of the two the evaporation of a weight of water nearly equal to itself, or, for the two, an evaporation equal to nearly twice the weight of the heating steam. The result is a double-effect apparatus. Multiple-effect installations can thus be arrived at in which there are evaporated 2, 3, 4, 5 or 6 lb. of water per lb. of steam used for heating the first apparatus. In practice, the limits to pressure at the first apparatus and to vacuum at the last one in the series generally limit the series to six. This process has led to a considerable saving in the evaporation of liquids. It was used for the first time in the manufacture of sugar by a French engineer, and is now general in the sugar industry in the shape of treble and quadruple effect apparatus. It has also been extended to the chemical industry. The process, however, does not appear capable of receiving any important improvement; as a matter of fact it now stands practically as it was thirty years ago.

Compression Method.—If we consider, in this instance also, a single-effect evaporator in which ebullition takes place at atmospheric pressure, and if by means of a mechanically operated compressor the steam produced in the ebullition chamber be drawn off and then compressed to a pressure sufficient for using it afresh for heating the evaporator itself, then evaporation will have taken place with an expenditure of energy equal to that supplied to the compressor. Since the difference in temperature between the heating chamber and the ebullition chamber is generally low (about 10 deg. C.) for ordinary liquids, the work absorbed by the compressor is also low. It is claimed that from the theoretical standpoint this method allows the evaporation of liquids under more economical conditions than obtain with multiple-effect apparatus. It was put forward as early as 1830, even before the use of the multiple-effect, but has not developed hitherto owing to the difficulty of obtaining steam compressors having a sufficient efficiency, owing also to the very great dimensions required for the compressors when the quantity of water to be evaporated is somewhat large. In 1830 the French engineer Pelletan advocated the use of a steam injector as steam compressor. This, owing to its simplicity, was a very tempting solution, but the trials which were carried out at the time did not succeed, owing to the low efficiency of the compressor-injectors then available. The consequence was an extended use of the multiple-effect process. The few attempts which have been made since to develop the compression system failed except in the case of a few small installations using a reciprocating compressor and having available hydraulic motive power at a low cost.

Thermo-Compressor.—Following these introductory remarks, we may state that Messrs. Prache and Bouillon, Paris, who have specialised in the question of the evaporation of liquids, took up afresh the compression method, working in conjunction with Messrs. Sautter Harlé, engineers, Paris, and in particular with Mr. J. Rey, the director of the latter firm. They made a complete study of the injector compressors, and after trials which lasted over a period of two years with the most varied types of apparatus, they perfected a new type which they have styled the "Thermo-compressor." This is illustrated in Figs. 1 and 2, on page 638.

This apparatus, specially designed for evaporation, has a much higher efficiency than the apparatus of the same type hitherto built, as was officially ascertained in a series of tests carried out on April 6, 1909, by the Paris Conservatoire National des Arts et Métiers. Official tests were also made in 1911 by the Bergakademie at the request of the Patentamt, Berlin, following upon an opposition lodged by Messrs. Koerting, Hanover, to the Prache and Bouillon German patents. The German firm claimed that the special shape of the Prache and Bouillon thermo-compressor had no value and did not confer an efficiency higher than that of the Koerting machines. The competitive trials were made at the Bergakademie by Professor Vater; they were most conclusive, and led to the rejection of the Koerting claim.

By reference to the diagram, Fig. 2, of a thermo-compressor, it will be seen that the liquid to be concentrated enters the apparatus at A; it flows through the tubes of the reheater B, becomes concentrated at the lower part, C, of the ebullition chamber, and is discharged at D. The live steam enters at E and draws in at F the heating steam, forming a compressed mixture of steam, which flows round the nest of tubes in the chamber G, thence passing up inside the ebullition chamber at H, a part returning through the tube I to do duty again, and the remainder flowing through the tube K to the reheater B. The reheater B and the ebullition chamber are each fitted with a pipe for draining off the condensed steam. The thermo-compressor proper is the live steam inlet at E.

The conjunction of the thermo-compressor with the evaporators led of a necessity to the designing of a new type for the latter, for the following reasons:—

In the first place, and in a given evaporator, the coefficient of evaporation, or, in other words, the quantity of water evaporated per square foot per hour for a given difference in the temperature of the heating steam and of the liquid, is the lower the greater the density or the viscosity of the liquid undergoing evaporation. Since the working of the evaporators is continuous, inasmuch as they are continuously travelled over by a liquid flow the amount of which governs concentration, it follows that if it be desired to concentrate a liquid in one single evaporator, this latter will be entirely filled by liquid completely concentrated, and the total heating surface will thus be in the worst possible conditions from the point of view of heat transmission.

This disadvantage is not a very marked one in the multiple-effect evaporators, where the liquid circulates from one machine to that next following, the successive machines being filled with liquids having an increasing density. The bad influence of increasing density is thus progressive.

Since the process of evaporation by compression secures the completion of the evaporation in one and the same apparatus, it was necessary so to arrange this latter that the circulation of the liquid may be methodically carried out. In order to obtain this, the Prache and Bouillon boiler is divided into a certain number of compartments, which the liquid runs through successively as its concentration increases.

In the second place, the efficiency of an evaporator working by compression depends solely upon the work absorbed by the compressor, and hence upon the degree of compression to be given to the steam, or, in other words, upon the difference in pressure, or temperature, existing between the heating steam and the steam given off by the liquid in ebullition.

Now, this difference in pressure for a given weight of water to be evaporated and its results may be illustrated as follows: If, for example, an apparatus evaporates, let us say, 6 lb. of water per square foot per hour with a difference in temperature of 10 deg. C., whilst another and better apparatus evaporates the same quantity of water with a difference in temperature of 5 deg. only, the work of compression in the latter will be half that in the former for the same weight of water evaporated. The efficiency of the second apparatus will therefore be double that of the first. This example shows the considerable value, in the case of evaporation by compression, of the evaporative qualities of the boiler.

Evaporator.—Guided by these considerations, and after studying the existing types of evaporators, Messrs. Prache and Bouillon adopted, after a series of trials at Messrs. Sautter Harlé's works, a type of evaporator specially designed to work in conjunction with their thermo-compressor; the main feature of this type being its high evaporative power under very low temperature differences. They based their *étude* on the following principles:—

The giving, both to the liquid undergoing evaporation and to the heating steam a maximum circulation velocity against the heating surface, combined with a minimum expenditure of energy. This is a well-known desideratum which is supported by theory and by the results of practical working. They succeeded in this by using nests of straight, parallel tubes, slightly inclined to the horizontal, the tubes having a given length for a given diameter. A sort of emulsion is formed in the heating tubes; in other words, by reason of these arrangements adopted for the boiler they are maintained incompletely filled with liquid, so that the mixture of steam and liquid circulating therein from bottom to top moves very rapidly. Non-heated circulation tubes bring down the non-evaporated liquid continuously from the top to the bottom ends of the tubes.

Owing to these arrangements it is claimed for the Prache and Bouillon boiler that it has—all other conditions remaining the same—an evaporative power about double that of the ordinary apparatus generally used. This was officially ascertained under the initiative of the Technical Committee of the Syndicate of French Manufacturers of Sugar in the course of experiments made in 1911 with a Prache and Bouillon evaporator of the type illustrated in Fig. 4, page 638, in operation at the Provins sugar works. This evaporator acted at the works in question as a recuperator for the waste steam of the cooking pans; it was heated by steam at a very low pressure and was combined with a condenser. It concentrated high-density sugar syrup. The tests made by the committee in question showed that this evaporator had a coefficient of evaporation double that of the ordinary apparatus.

The design of the evaporator will be seen by reference to the diagram, Fig. 3, on page 638. The liquid to be concentrated enters the apparatus at A, whilst the concentrated liquid flows out at the bottom part, B, of the level adjusting device. The heating steam enters at C; the condensed steam is discharged at D, and the non-condensable gases escape at E. F forms the ebullition chamber, up which the steam rises after circulating round the nest of tubes G, these latter being incompletely filled at their higher part with the liquid requiring concentration. H is a circulation tube for the liquid under treatment.

Auto-Condenser.—The grouping together of the thermo-compressor with the Prache and Bouillon evaporator constitutes the complete apparatus styled "auto-condenser," since the evaporator itself condenses a part of the steam which it has produced after this has been compressed. The excess of steam non-utilised afresh, and which is practically equal to the weight of live steam supplied to the thermo-condenser, is discharged outside after having flowed through a reheater which utilises a portion of it for bringing the liquid to be concentrated to its ebullition temperature, This excess of steam can be utilised for various ends, according to the purpose of the installation. When possible, the auto-condenser always carries out evaporation at atmospheric pressure; in this case its action is extremely simple, the apparatus having no condenser and no pump of any sort

The efficiency of the auto-condenser depends as a matter of course upon the nature of the liquid to be concentrated, the degree of concentration aimed at, and the pressure of the live steam supplied to the thermo-compressor. It varies from 2.5 lb. to 4 lb. of water evaporated per lb. of live steam consumed. The apparatus therefore has an efficiency equal to that of treble and quadruple-effect apparatus, and has over these, apart from the advantage of greater simplicity, the other advantage of requiring no condenser.

In the multiple-effect apparatus, which generally works under a vacuum, the condenser demands an expenditure of power, and in the water of condensation are lost all the heat units contained in the steam which proceeds from the last apparatus in the series. In the auto-condenser, on the other hand, which can almost invariably work at atmospheric pressure, the heat proceeding from the liquid can easily be utilised for reheating, thanks to its high temperature; at any rate, if there is no use for it, its evacuation is effected without expenditure of energy. ←

Owing to the special arrangement of the Prache and Bouillon evaporator, owing also the methodical circulation which takes place inside it, and to the use of small tubes, which results in a small internal volume, concentration is very rapid and the continuance of the product in the apparatus can be reduced to a few minutes' duration. This makes it possible to carry out in these evaporators and at atmospheric pressure concentrations which formerly were carried out at low temperature under a vacuum in the older apparatus, such, for example, as the concentration of milk and of certain vegetable extracts which are highly sensitive to the action of heat. Moreover, as above stated, the steam which is not sent back to the thermo-compressor and which escapes at atmospheric pressure can easily be turned to account for heating the liquid previous to

THE PRACHE AND BOUILLON EVAPORATING PLANTS.

CONSTRUCTED BY MESSRS. PRACHE AND BOUILLON, ENGINEERS, PARIS.

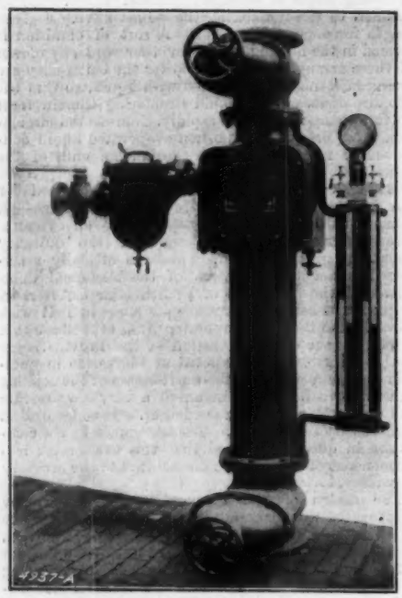


Fig. 1. Thermo-Compressor.

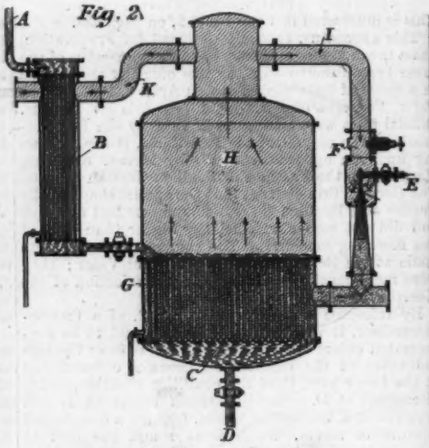


Fig. 2. Thermo-Compressor.

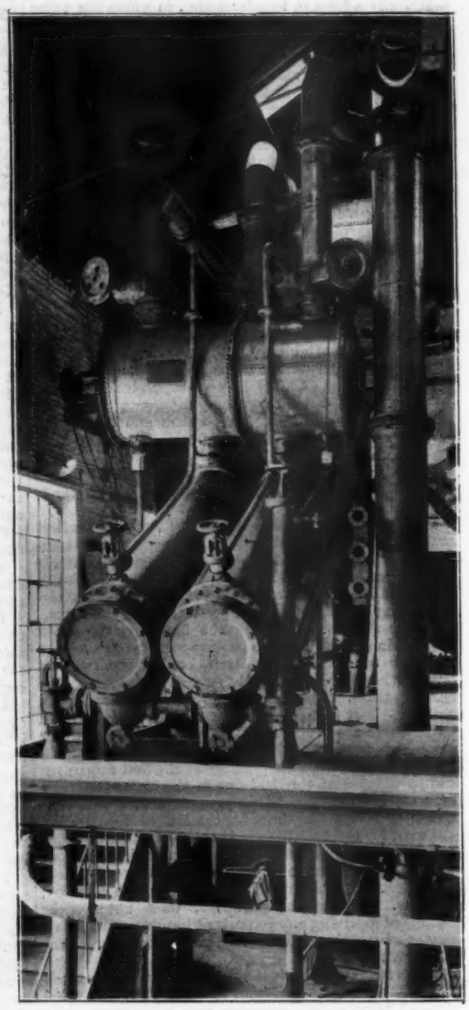


Fig. 4. Evaporator.

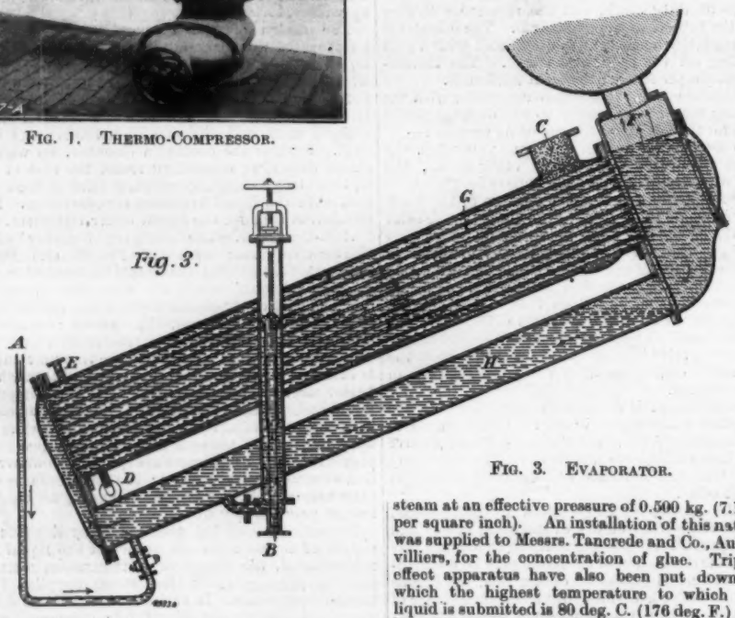


Fig. 3. Evaporator.

concentration, or for heating the boiler feed-water, and when all the heat units contained in this steam can be recuperated the concentration of the liquid is obtained practically without any cost.

The auto-condenser of the rectangular type is shown in Figs. 5 to 7, page 630. This is used for installations having a capacity below 1,500 kg. per hour. Fig. 8 illustrates the circular type of auto-condenser for large outputs; in this type the different compartments through which the liquid runs during concentration are placed one above another instead of side by side as in the rectangular type.

The diagram of an auto-condenser, Fig. 7, shows the working to be as follows:—The liquid to be concentrated is stored in the tank A, it enters the nest of tubes B, flows through the piping C to the tubes D and the circulation tube E, the concentrated liquid leaving the machine at F. The live steam enters at G, flows through the thermo-compressor at H, draws with it the return steam from I, the compressed steam mixture flowing through the tubes K and round the nest of tubes D, and the process repeating itself as stated in the description of Fig. 2.

Prache and Bouillon Boilers as Multiple-effect Evaporators.—The high evaporative power of the Prache and Bouillon boiler with low temperature differences renders it a very satisfactory multiple-effect evaporator, and it has the advantage of enabling the insertion of a large number of effects between the initial pressure and the condenser vacuum. Installations have been put down having seven effects, the first shell being heated by steam at an effective pressure of 0.500 kg. (7.1 lb. per square inch). An installation of this nature was supplied to Messrs. Tancrede and Co., Aubervilliers, for the concentration of glue. Triple-effect apparatus have also been put down in which the highest temperature to which the liquid is submitted is 80 deg. C. (176 deg. F.); such, for example, as the triple-effect installation for the concentration of tanning extracts supplied to Messrs. Cronier-Quérelle, Ponteils (Gard.).

Auto-Condenser Combined with Multiple-effect Plant.—By combining an auto-condenser working at atmospheric pressure with evaporators connected in series for working on the multiple-effect principle, a condenser serving the last set, an arrangement is obtained the efficiency of which can reach a very high figure. In this manner, if an auto-condenser evaporating 3 lb. of water per lb. of steam sent to the thermo-compressor be followed by a series of six machines mounted in multiple-effect, the installation is capable of evaporating about 8 lb. of water per lb. of steam used, or 60 lb. of water per lb. of coal. An installation of this type is shown in Fig. 9, page 642. The following table gives the efficiency of the ordinary process compared with similar apparatus, but having the first set fitted with the Prache and Bouillon thermo-compressor. The figures in the second and third columns indicate the weight of water evaporated per lb. of coal:—

—	Ordinary Process	Prache and Bouillon Process.	Difference in Favour of P. and B. Process.
	lb.	lb.	Per Cent.
Simple-effect apparatus ..	7.50	22.50	66
Double-effect ,, ..	15.00	30.00	50
Treble-effect ,, ..	22.50	37.50	39
Quadruple-effect ,, ..	30.00	45.00	33
Quintuple-effect ,, ..	37.50	52.50	29
Sextuple-effect ,, ..	45.00	60.00	25

Messrs. Prache and Bouillon also build forms of apparatus for special duties, among which may be mentioned the following:—

Crystallising Evaporator.—This serves to concentrate liquids which during the evaporation deposit crystals, such as sea-water salt, various potash and soda salts, salt glycerinous lyes of soap manufacture, &c. It is shown in Fig. 10, page 642. In ordinary tubular boilers the crystals attach themselves to the tubes and prevent any further evaporation. In the machine illustrated the liquid does not boil in the heating tubes; ebullition takes place in separate receivers, so shaped that no deposits can be formed. The apparatus consists of two closed vertical cylindro-conical receivers or evaporators connected together at their lower part by means of a superheater which is steam-heated. The liquid requiring concentration contained in the apparatus acquires a motion which compels it to flow alternately from one evaporator to the other through the superheater. The height of the liquid above the level of the superheater is sufficient for the liquid to flow through the latter and to receive in the process a superheat which brings its temperature above the boiling-point corresponding to the pressure which rules on the surface in the evaporators. Boiling thus commences only at the moment when the liquid, in each of its shiftings, arrives in the low portion of each evaporator. The displacement of the liquid from one evaporator to the other is carried out automatically by a mechanical distributor operated by bodies immersed in one of them, and which alternately put the higher capacity of this evaporator in relation first with atmospheric pressure and then with the slightly higher pressure. The

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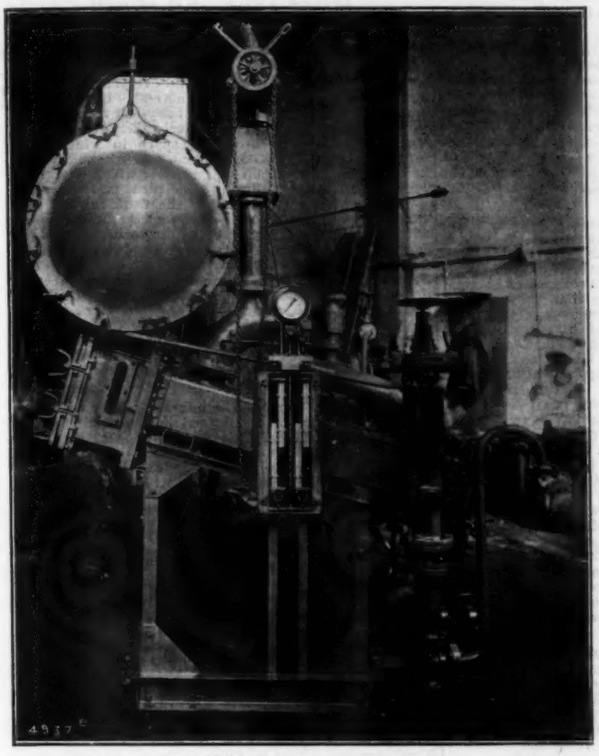


FIG. 5. AUTO-CONDENSER, RECTANGULAR TYPE.

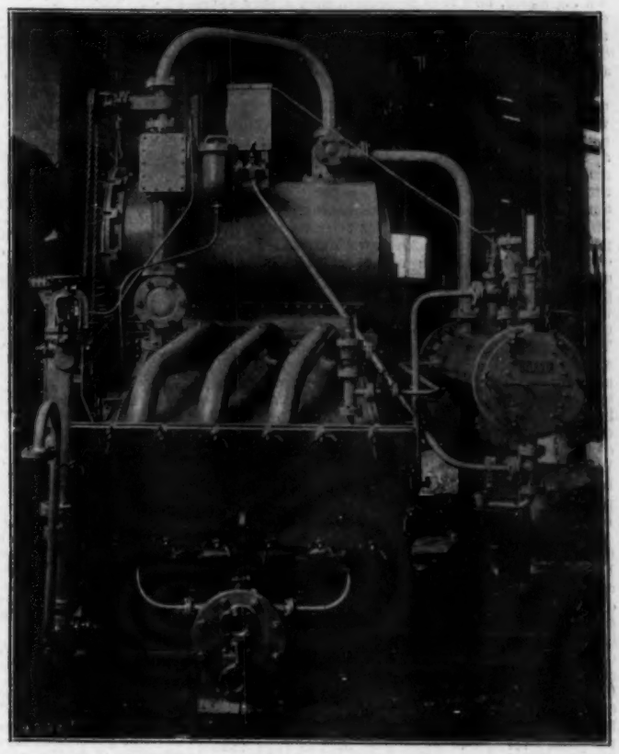


FIG. 6. AUTO-CONDENSER, RECTANGULAR TYPE.

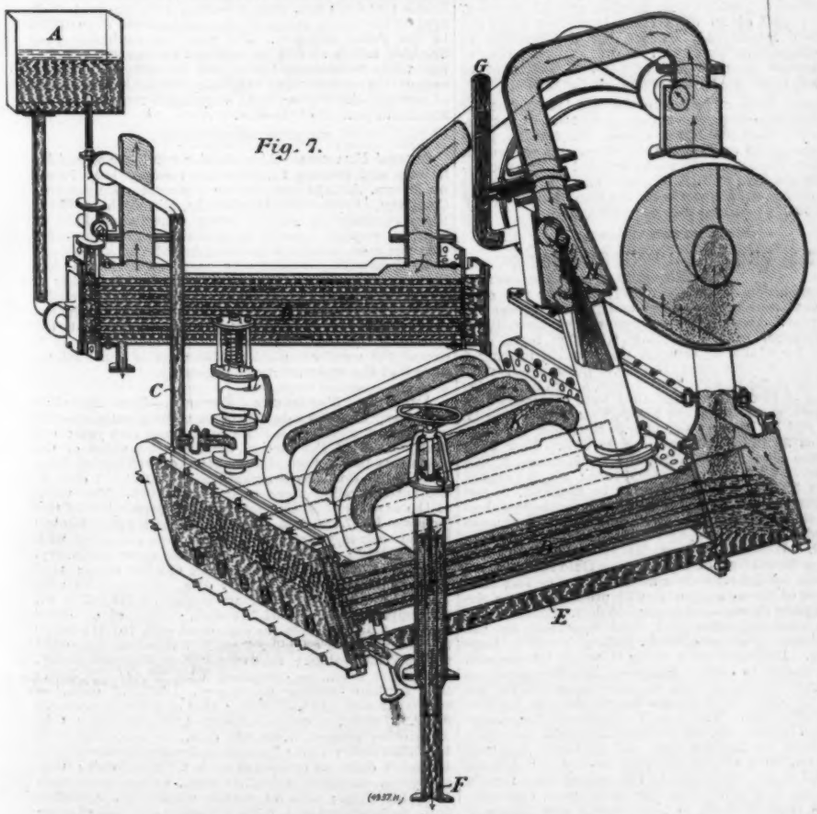


Fig. 7.

FIG. 7. AUTO-CONDENSER, RECTANGULAR TYPE.

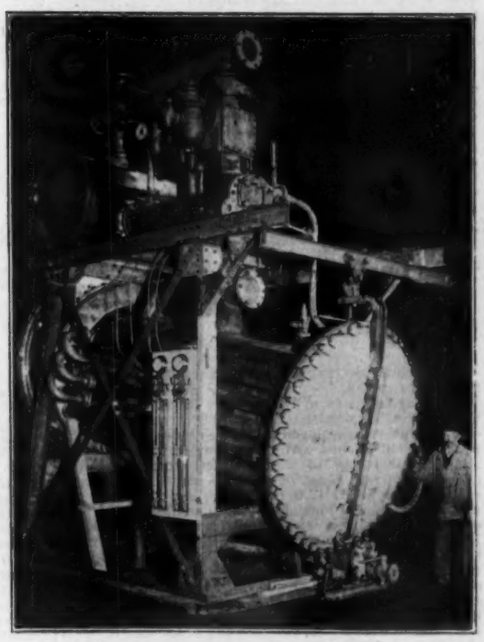


FIG. 8. AUTO-CONDENSER, CIRCULAR TYPE.

apparatus can work under a vacuum in simple, double and treble effect. The steam consumption required for the displacement of the liquid is very limited. The superheater may be made with vertical tubes and double circulation, or with inclined tubes, or even with horizontal tubes, having simple circulation. A receiver is located at the lower part of the machine in which the

salt is deposited and from which it can be removed during working. The alternate and rapid circulation of the liquid in every portion of the apparatus completely prevents any deposition of salt. Moreover, the crystals can be maintained as long as may be in the boiling liquid, and thus increase in size, a very appreciable advantage in the industries where crystals have to be produced of given dimensions. The mechanical distributor has been specially designed to combine strength with reliability.

The Prache and Bouillon apparatus are used in the manufacture of sugar, glucose, tanning and tinctorial vegetable extracts, meat extracts, condensed milk, glue, gelatine, in the extraction of diverse salts, such as sodium nitrate, and in the treatment of all kinds of residual waters. They are used also in the preparation of distilled water by the evaporation of impure and sea water. For sea-water distillation the company build two installations, one for relatively small outputs, having an auto-condenser working with a thermo-compressor without the use of a vacuum, *i.e.*, at atmospheric pressure entirely and requiring no moving parts. With this, 4 lb. of distilled water are obtained with 1 lb. of steam, corresponding to a coal consumption of about 30 lb. per 1000 lb. of distilled water obtained. These installations are portable. The installations for a larger output consist of an auto-condenser, followed by a multiple-effect system working under a vacuum; with these, about 8 lb. of distilled water are obtained per lb. of steam spent, equal to about 70 lb. of distilled water per lb. of coal, corresponding to a consumption of 15 lb. of coal per 1000 lb. of distilled water obtained. When using liquid fuel instead of coal for heating the boilers, it is claimed that the yield is increased in the proportion of the increased heat developed, and 100 lb. of distilled water is obtained per lb. of oil fuel.

By combining their machines with internal combustion engines, in which the oil fuel is used directly, Messrs. Prache & Bouillon state that they can obtain as much as 150 lb. of distilled water per lb. of oil. In both types of installation the distilled water is cooled and aerated to render it potable. It can easily be mineralised to give it all the required properties of a good drinking water. It is easy also to add to both plants a crystallising evaporator to recover the salts from the water treated. Fig. 11, on page 642, shows a complete apparatus for small output, with steam boiler, refrigerator and reserve receiver. The larger plants are formed of apparatus of the type shown in Fig. 9.

At the present time over 75 Prache and Bouillon installations have been put down in France, Italy, Russia, Spain, England, Germany and South America for the various manufactures enumerated above.

Working of the United States Railways in 1916.—In 1916, for the first time in 10 years (1909 barely excepted), says the Bureau of Railway News and Statistics, Chicago, the operating ratio of the railways of the United States was within the margin of safety—the margin that insures adequate service for the present and adequate facilities for the future. Computed from the monthly returns to the Interstate Commerce Commission, the income account of the railways of the United States for an average of 258,988 miles of line operated during the year ended June 30, 1916, yields the following results:—

Operating revenues	3,508,529,950 dols.
Operating expenses and taxes ..	2,452,022,700 ,,
Net operating income ..	1,056,507,250 ,,
Operating ratio, including taxes	69.88 per cent.
Below the line of safety ..	0.12 ,,
The line of safety	70.00 ,,

Electro-Chemistry and Electro-Metallurgy in Switzerland, 1915.—According to the Report on the Trade and Industry of Switzerland for the year 1915, the Swiss electro-chemical and electro-metallurgical industry kept well employed that year on the whole. The production of calcium carbide rose to nearly 60,000 tons. About 10,000 tons of this product remained in the country, the rest, about 55,000 tons were exported and estimated as worth 12.5 million francs. In 1913 the figures were 31,000 tons and 7·5 million francs. Of the exports 48,600 tons went to Germany, 3,900 tons to Belgium, 2,200 tons to the Netherlands. Most of the kalksbrikshoff, of which 10,000 tons were produced, went to France. The production of corundum and other abrasives did not exceed 800 tons. The production of aluminium was much increased, in spite of all difficulties; figures are not given, however. About 14,000 tons of ferro-silicon were made, but only 300 or 400 tons of ferro-chrome and 150 tons of ferro-tungsten, owing to the dearth of raw materials. The important potassium chlorate manufacture had to be stopped altogether for this reason. Works making chlorate of sodium, ammonia, and also electrolytic caustic soda were, on the other hand, kept very busy. The demand for nitric acid exceeded the supply, so that private orders were not all fulfilled. Most of the oxygen produced, 380,000 cub. m., was made by the Linde process; about 35,000 cub. m., and double that quantity of hydrogen, were generated by electrolysis. Hydrogen peroxide works, commanding about 350 h.p., are being erected.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several Colonial and foreign engineering projects taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, 73, Basinghall-street, E.C.

New Zealand.—The Office of H.M. Trade Commissioner in New Zealand calls attention to notices appearing in the official *New Zealand Gazette* announcing the grant of licences to the Martinborough town board, the Kaitangata borough council, and the Waimairi county council to instal and maintain in their respective districts electric lines for lighting, power and heating purposes. The *Gazette* also publishes a notice to the effect that the Thakau town board has decided, on a poll of the ratepayers, to borrow the sum of 12,000*l.*, to be devoted to public works in that district.

Russia.—According to the *Vyestnik Finansov*, Petrograd, the Ministry of Communications has prepared a Bill, at the request of the Duma, for the "notification of centres of water power from waterfalls, or stretches of water suitable for the supply of such centres, of national or public importance." It appears that early in 1913 the Duma was impressed with the necessity for the organisation and development of the water-power resources of Russia and wished to have legislation prepared with these ends in view. Up to the present, Russian law has never provided for the utilisation of water power, except in the case of ordinary mills. Permits to make use of water power have been more in the nature of certificates that the Ministry of Communications considered that the proposed utilisation would not interfere with navigation, than of concessions. These certificates were only issued after consulting the local owners of water frontages, and thus the utilisation of water power depended entirely on the consent of private owners. The present Bill, without making any attempt to decide as to the ownership of water power, proposes to empower the Government to declare any waterfall, or stretch of water, capable of being used as a source of water power, as being of national importance, and to take possession of such source of power, either for direct Government use, or with a view to granting concessions for its use in industries which it is desirable to foster.

Spain.—The *Gaceta de Madrid* notifies that projects for the installation of water supply and sewerage system at the town of Manzanares will be received, within a period of three months from December 3, at the "Secretaria del Ayuntamiento," Manzanares. The project submitted must be accompanied by plans and estimates, and full particulars must be given regarding the construction of buildings, the necessary plant, pipes, &c. A prize of 5,000 pesetas (about 200*l.* at par) will be awarded for the project selected by the municipality. The *Gaceta* also notifies that tenders will be received, within a period of 30 days from December 6, at the "Secretaria Municipal," Linares, for the erection of school buildings at that town at an estimated cost of 92,658 pesetas (about 3,700*l.* at par). A period of 16 months will be allowed for carrying out the works.

Uruguay.—With reference to the call for tenders for the construction of a public market at the town of Artigas, it is notified that the *Diario Oficial*, Montevideo, publishes a resolution authorising the municipal authorities of Artigas to commence the works referred to, by arrangement with the firm of J. A. Casterés and Co., which has agreed to carry out the works for the sum of 25,734 pesos (about 6,000*l.* at current rate of exchange).

NOTES FROM THE UNITED STATES.

Philadelphia, December 6.

The conclusion is now generally held in the steel market that still higher prices will prevail during the coming year. Railroads are buying very liberally of rails, November orders reaching 1,100,000 tons, with prospects for a similar tonnage this month, making a total already booked for 1917 of 3,000,000 tons. Wire products have again advanced 3 dols. a ton, and plates are selling at three times what they were two years ago. Billets and sheet bars are moving steadily upwards. Pig-iron will be higher next year. Bessemer has sold as high as 35 dols. and basic at 30 dols. New York agents have sold 100,000 tons, Buffalo furnaces, 25,000 tons; Cleveland furnaces, 100,000 tons; besides export orders for 30,000 tons of Bessemer to England, 30,000 tons to France, and 10,000 to Italy. November production was the highest on record. The warehouse advance in finished steel is 5 dols., and warehouse stocks are at a low level. Western oil and gas interests are in the market for 20,000 tons of pipe and an Ohio company for 10,000 tons for delivery after next July. The increased production of ferro-manganese will probably lower the imported price at seaboard below 165 dols. Several large projects involving structural steel appeared on the market during this past week, calling for very large quantities. Railroads are rushing in orders for cars and are now unable to obtain deliveries, in some cases not sooner than six months and in other cases not for ten months. To-day the inquiries before the car builders call for 20,000 cars. The New York Central has placed orders for 175,000 tons, the Pennsylvania will place very soon an order for 205,000 tons, and the Great Northern 45,000 tons, with orders pending to-day for 450,000 tons. All of the conditions in the steel market remain virtually as they have been for weeks past, excepting that it is more difficult to place orders and that also prices are pointing upwards. All things considered the steel industry is meeting the enormous requirements, but the uncertain factor is as to the pressure for mill supplies between now and the time when booked orders will be filled. The lesser steel-consuming interests are active buyers.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—In this, the last week of the year, a redoubled effort is being made to get as much of the finished material as is possible sent out from the steel works in the West of Scotland, and everyone is working at the highest pressure to attain this end. Little thought is being given to the idea of a holiday—or rest, rather—by the workers, although many steelmakers are anxiously anticipating a short breathing space in which some urgently required repairs to plant and machinery may be executed. The strain on machines which have been running unceasingly during the past two-and-a-half years has been colossal, and if the work for the War Office and the Admiralty is to be successfully gone on with everything must be in first-class condition. Of the contracts at present in hand, shell bars and billets are still prominently in the foreground, while sections and shapes for Admiralty requirements make a good second. So great, indeed, is the home demand for finished and semi-finished steel material that practically not a single ton is being shipped abroad except for the use of the Allies. The review of the year shows that an extraordinary tonnage in this class of work has been turned out in the West of Scotland, and that, too, under conditions never known before.

Malleable Iron Trade.—The intense activity which has characterised the works engaged in the production of malleable iron shows no slacking-off whatever, the anxiety of the makers being to speed-up deliveries as far as possible—no easy task under existing conditions. "Crown" bars keep steady at about 14*l.* 10*s.* to 14*l.* 15*s.* per ton.

Scotch Pig-Iron Trade.—Business in the Scotch pig-iron trade continues to run on very active lines, and makers have been enabled to place at the disposal of consumers increased supplies. Pressure for all grades, for hematite perhaps most of all, remains as active as ever. Over the week, prices are practically unchanged.

Vacancy in the Clyde Trust.—The lamented death of Mr. Archibald Colville, of Motherwell, has created a vacancy in the Clyde Trust, of which he was an honoured member, representing the steel industry for many years. It is expected that Mr. James M. Strain, of Messrs. John Watson, Limited, and of the Lanarkshire Steel Company, Limited—a gentleman, of course, intimately connected with the steel and coal trades—will be put forward as a candidate to fill the vacancy.

Clyde Workmen and Prohibition.—Following the recent meeting of employers a meeting of the Engineering and Shipbuilding Federation of Trades (Clyde District) was held a few days ago, when a lengthy telegram protesting against the action taken by the masters was despatched to the Prime Minister. The men are indignant that drinking habits should be imputed to them as a body, and while recognising the urgent necessity of a steady output, they make some suggestions as to the best means of accomplishing what is so very much required for the successful pursuit of the war.

Smiths' Hearths.—An extensive catalogue of smiths' hearths and heating furnaces has recently been issued by Messrs. Alldays and Onions Pneumatic Engineering Company, of Great Western Works, Birmingham. In it there is described almost every conceivable kind of heating appliance used in smithing work—cast-iron, wrought steel and brick hearths, hearths with chimneys and others with down-draught, some supplied with blast by hand and others with belt or electric driven fans or compressed-air ejector draught. There are coppersmiths' hearths, hearths specially arranged for export, and boiler-smiths' plate-bending hearths. And throughout the catalogue full particulars and prices are given. It is one of the most complete publications of the kind we have had the opportunity of reviewing.

American Machinery Exports.—The American machinery export trade continues to be greatly affected by the war, which in a little more than two years has nearly doubled the foreign demand, the value of the shipments in the first nine months of 1916 having been 168,570,387 dols., as compared with 91,674,277 dols. in the corresponding three quarters of 1915. The value of the exports of adding machines to September 30 this year was 1,047,886 dols., as compared with 420,758 dols.; that of cash registers, 1,254,263 dols., as compared with 176,263 dols.; that of elevators and elevator machinery, 9,374,419 dols., as compared with 638,350 dols.; that of gasoline engines, 12,165,657 dols., as compared with 4,106,252 dols.; that of steam engines, 8,278,243 dols., as compared with 4,054,341 dols.; that of all other engines, 3,926,284 dols., as compared with 767,418 dols.; that of parts of engines, 7,859,717 dols., as compared with 3,233,649 dols.; that of metal-working machinery, 63,218,202 dols., as compared with 30,844,199 dols.; that of flour-milling machinery, 1,807,979 dols., as compared with 1,826,660 dols.; that of mining machinery 6,492,297 dols., as compared with 4,980,076 dols.; that of printing presses, 1,430,045 dols., as compared with 1,065,529 dols.; that of pumps and pumping machinery, 4,072,779 dols., as compared with 2,298,447 dols; that of sewing machines, 4,209,705 dols., as compared with 4,469,366 dols.; that of textile machinery, 2,609,985 dols., as compared with 1,386,619 dols.; and that of type-writing machines, 8,243,380 dols., as compared with 5,121,475 dols.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Little business, comparatively speaking, has been done during the last few days in the coal trade, the latest quotations to hand being the following, the price of best Admiralty large and best seconds steam coal remaining nominal, as formerly:—Secondary qualities, steam coal, 28*s.* to 30*s.*; Monmouthshire Black Veins, 28*s.* to 30*s.*; ordinary Western Valleys, 27*s.* 6*d.* to 30*s.*; Eastern Valleys, 27*s.* to 30*s.*; best bunker smalls, 18*s.* to 20*s.*; and cargo smalls, 14*s.* to 16*s.* In regard to bituminous coal, the best households have made 25*s.* 6*d.* to 26*s.* 6*d.* at the pit mouth, whilst No. 3 Rhondda large have been quoted 28*s.* to 30*s.*; smalls, 18*s.* to 20*s.*; No. 2 Rhondda large, 27*s.* to 28*s.*; smalls, 17*s.* to 19*s.*; patent fuel has made 35*s.* to 37*s.*; and special foundry coke 62*s.* 6*d.* to 67*s.* 6*d.*; good foundry coke, 57*s.* 6*d.* to 60*s.*; and furnace coke, 47*s.* 6*d.* to 52*s.* 6*d.*, these three latter sets of prices being for export. Pitwood, ex ship, has made from 49*s.* to 50*s.*

Western Trade Matters.—The Taff's Well Dolomite Company, Limited, has recently been registered, with a capital of 1,200*l.* in 1*l.* shares, to take over a lease of lands at Taff's Well with a view to search for lime minerals and to carry on the business of cement manufacturers, lime burners, brick makers, quarrymen, &c.—The total profit from trading, including interest and sundry fees, of the Griffiths-Lewis Steam Navigation Company, Limited, for the year ended September 30, 1916, amounts to 55,865*l.* 18*s.* 4*d.* Dividends to the amount of 20 per cent. for the year have been paid, and sundry capital items have been written off, leaving a balance to be carried forward of 37,738*l.*, out of which the special taxation will be provided. The company's steamers have been almost continuously in the service of the British and allied Governments. The steamers Ecclesia and Sidmouth were sunk by enemy submarines, and the steamer Rachel was purchased.—At a recent meeting of the directors of the Consolidated Cambrian, Limited, the resignation of Lord Rhondda from the board was received, and Lady Mackworth was elected to fill the vacancy. Mr. Edward A. Mitchell Innes was elected chairman in place of Lord Rhondda. At meetings of the four constituent companies Lady Mackworth was elected a director in place of Lord Rhondda, Mr. Peter Haig Thomas being appointed managing director. Mr. Edward A. Mitchell Innes was elected chairman of the Glamorgan Coal Company, Limited, Mr. T. J. Callaghan chairman of the Naval Colliery Company (1897), Ltd., and Mr. Chas. A. G. Pullin chairman of the Britannic Merthyr Coal Company, Ltd, Mr. J. H. Thomas (brother of Lord Rhondda) is chairman of the Cambrian Collieries, Limited.—At a meeting of the directors of D. Davis and Sons, Limited, and the Welsh Navigation Steam Coal Company, Limited, Mr. Peter Haig Thomas was appointed chairman and managing director of both companies, and Mr. A. Mitchelson deputy-chairman of both companies. Lady Mackworth and Mr. H. Seymour Berry were elected on both directorates.

WOLFRAM FROM THE MALAY STATES.—The demand for tungsten ores for the manufacture of war material has prompted inquiry into the Empire resources of these ores. In the last report of Mr. W. Eyre Kenny, Senior Warden of Mines, Federated Malay States, it is stated that the total tonnage of tungsten ores exported from those States in 1915 amounted to 291 tons, in 1914 to 261 tons and in 1913 to 225 tons. The greater quantity was low-grade ore, and carried less than 65 per cent. of tungstic acid. Tungsten ores aggregating 407 tons were imported from other countries and re-exported after treatment at separating works in the States, but are not included in the above-quoted figures. There is nothing to show to which countries the tungsten was exported. The value of wolfram alone exported from the Federated Malay States in 1915 was 32,174*l.* It is not generally realised that tungsten ores do not occur in the Federated Malay States in defined deposits, and that by far the greater bulk is found in small quantities, irregularly intermixed with tin ore and valueless matter. These facts render it impossible to obtain any large increase in output. The ore is also mainly of a low grade, which is not a favourable factor. Every effort has been made by the authorities to stimulate production, however. Export duty has been suspended, and special terms are given to prospectors and as regards mining rights. Turning to the statistics of the Straits Settlements, more light is obtained with regard to the supply of wolfram from the Malay Peninsula and Archipelago. The total value of the exports for three years was as follow:—1913, 74,638*l.*; 1914, 54,130*l.*; 1915, 69,900*l.* Wolfram was imported into the Colony from the following countries:—

—	1913. Tons.	1914. Tons.	1915. Tons.
Burma	115	28	22
British Malay States ..	268	230	220
Siamese Malay States ..	270	179	266
Dutch Islands	—	—	18

It is interesting to note to which countries the wolfram was exported, and the principal purchasers are given below:—

—	1913. Tons.	1914. Tons.	1915. Tons.
Belgium	21	—	—
France	129	103	182
Germany	527	307	—
United Kingdom	5	76	400

It should be explained that the excess of exports over imports is not due to the mining of wolfram in the Straits Settlements, but to its extraction from the tin ore sent for treatment to the great tin-smelting establishments in the colony.

CATALOGUES.

Mill Furnishing.—The Belgian Specialities Company, Limited, of 10, Bishopsgate-avenue, London, E.C., have forwarded to us a price list of millwrights' requirements, such as plummer blocks, hangers, couplings, pulleys, shafting, &c., which appear to be very reasonable in price.

Electric Lamp Locks.—A leaflet issued by Messrs. "Lamlok," of 18, Ranelagh-gardens, Hammersmith, London, W., illustrates a very simple form of locking ring, for preventing the theft of electric light globes. It can be used with any standard bayonet socket and effectually prevents the removal of the lamp without the use of a special key.

Half-Watt Lanterns.—Messrs. Crompton and Co., Limited, of Chelmsford, have sent us a price sheet of lanterns specially designed to accommodate half-watt lamps, of up to 1,500 watts. They are so arranged as to throw all the light downwards, and give an even distribution over a wide area without impairing the efficiency of illumination by the adoption of opalescent glass globes.

Big Locomotives.—A booklet, which gives in a very concise form the leading particulars of a number of locomotives, has been forwarded to us by the Baldwin Locomotive Works, of Philadelphia, Pa., U.S.A. These engines are all of the "Mikado" type—that is to say, have two leading wheels, eight coupled drivers and a pair of trailers, and the illustrations represent examples from most of the railways of North America.

Crude Oil Engines.—Messrs. Robey and Co., Limited, of Lincoln, have issued a revised edition of their catalogue of crude oil engines working on the two-stroke cycle system. These engines are made in sizes ranging from 6 up to 200 brake horse-power, and work on the semi-Diesel system. The catalogue gives a good description of the operation of the engine, and is well illustrated by both line and half-tone blocks.

Lightning Arresters.—A very compact and effective form of lightning arrester, for use on continuous-current circuits, is described in a leaflet just issued by the British Thomson-Houston Company, Limited, of Rugby. It comprises a single spark-gap protected by a magnetic blow-out coil and is contained in a strong porcelain case. The spark-gap terminals are readily accessible for inspection and adjustment.

Electric Illumination for Railways.—One of the most recent publications issued by Messrs. Holoplane, Limited, of 12, Cartaret-street, Queen Anne's-gate, London, S.W., deals with the illumination of railway premises and rolling stock. Some data are given as a guidance in the apportionment of illumination, and the prices of Holoplane reflectors suitable for railway yards included. The body of the booklet is devoted to illustrations of typical lighting installations on English railways.

Gas Stoves and Cookers.—Messrs. John Wright and Co., of Essex Works, Birmingham, have lately issued a catalogue specially devoted to cooking apparatus, fired by gas, suitable for installation in canteens, or any establishment where a large number of people must be catered for at one time. The apparatus catalogued includes cookers, boilers, hot-plates, steamers, &c., while the illustrations represent typical installations capable of cooking meals for up to 2,000 persons at one time.

Blowing and Exhausting Fans.—From the Sturtevant Engineering Company, Limited, of 147, Queen Victoria-street, London, E.C., we have received a booklet describing their "Monogram" fans. These are of the centrifugal type, and can be supplied with the discharge branch pointing either upwards, downwards, to the right or to the left. The bearings are self-aligning and lined with white metal. These fans are made in a dozen different sizes with outlets ranging from 4½ in. up to 24½ in. in diameter. The air is delivered at pressures ranging from 6 up to 12 in. of water.

Pulley Blocks.—Messrs. Herbert Morris, Limited, of Loughborough, Leicestershire, have recently brought out a new type of pulley block, in competition with the imported American geared blocks, which have found a certain vogue of late. The blocks made at Loughborough are, however, of a more substantial design and proportioned to carry their loads at the rate of 2,240 lb. per ton—not 2,000 lb. per ton, as is the case with American tackle. A list just published by the makers gives particulars of these blocks, together with those of several other patterns.

Life-saving Rafts for Steamers.—A sheet issued by Mr. Leoline Edwards, of Twickenham, Middlesex, depicts a system of utilising a special form of deck chair to make rafts, in case of emergency on shipboard. The chairs are, in appearance, very similar to the ordinary canvas deck chair, but four of them have sufficient buoyancy to support 12 persons, and, it is claimed, the four can be lashed together for this purpose and launched in 1 minute and 25 seconds. The chairs have been given the name "Quidos," and are approved by the Board of Trade.

Portable Engines.—Messrs. Marshall, Sons and Co., Limited, of Gainsborough, have sent us a copy of their "Publication No. 979." This deals with portable and semi-portable engines working with saturated steam at pressures of about 120 lb. per sq. in. The engines are of the single or double-cylinder and compound types and are fitted with Messrs. Marshall's patent cambered top firebox, which obviates the necessity for roof stays, and thus greatly facilitates the maintenance of the boiler in good working condition. Units of from 3 up to 40 n.h.p. are included in the catalogue.

Shell-making Chucks.—One of the greatest difficulties which has been encountered in obtaining the maximum output in machining shells has been due to the lack of satisfactory chucks. This has, however, been overcome by Messrs. J. and H. McLaren, of Midland Engine Works, Leeds, by adopting a very powerful lever and screw action in tightening up the chuck. A set of chucks has been designed for holding various sizes of shells during all the processes of finishing. These devices are described in a well-illustrated catalogue, which has recently been sent out by the makers.

Prevention of Corrosion.—The system of preventing the corrosion of boilers, condensers, &c., which has been developed by the Cumberland Engineering Company, of 6 Lloyd's-avenue, London, E.C., is based on the theory that all corrosion entails an electrolytic action. Thus by setting up a counter electro-chemical action of sufficient force the corrosion should be stopped. This force is provided in the form of a low-tension current, furnished by a small motor-generator, and distributed by anodes placed in the object to be protected. The process has already been adopted by a large number of the premier steamship companies and power users.

Automatic Electric Generating Plant.—A type of petrol-driven electric generating plant which should prove very popular as an emergency set on board ship, for wireless telegraphy purposes, has been brought out by Messrs R. A. Lister and Co., of 47, Victoria-street, Westminster. By means of an electric relay system and a storage battery, which is always kept fully charged, the dynamo is used, as a motor, to start the engine whenever the main supply voltage falls below a predetermined limit. An arrangement is also provided to start the set, automatically, every day, and thus ensure that it is always in proper running order—ready to deliver electric current immediately on the failure of the main supply.

Superheaters.—An improved form of superheater, for use in connection with Cornish and Lancashire boilers, has recently been introduced by Mr. John Thompson, of Wolverhampton. The novelty lies in the method of inserting the tubes into the headers. The tubes are of the usual U-shape and have taper sockets at the ends. Each pair of these sockets is forced into corresponding holes in the headers by means of a right and left hand screw. The result of this arrangement is that a burnt-out tube can be removed in a very short space of time, and a sound tube put in its place, without disturbing any other part of the boiler.

Petrol Wagons.—Although the Basingstoke works of Messrs. J. I. Thornycroft and Co., Limited, whose London address is Caxton House, Westminster, are engaged entirely on War Office contracts, the firm are not losing sght of the fact that some day soon they will be able to revert to the construction of commercial vehicles. With this idea in view they have recently issued a new and enlarged catalogue of vehicles adaptable to all kinds of trade purposes. The wagons are designed to carry useful loads of from 25 cwt. up to 5 tons. But the general features of the Thornycroft products are so well known to the readers of ENGINEERING that it is unnecessary to enlarge upon them here.

Air Compressors and Pneumatic Hammer Drills.—Bulletin 34-N. of the Chicago Pneumatic Tool Company, Fisher Building, Chicago, U.S.A., deals with single-cylinder air compressors, driven by steam or belting. The valves of these compressors are of the flat disc type and are guaranteed against defects or breakage for a period of one year. The outputs range from 52 up to 1,113 cub. ft. per minute. Another list from the same company describes the Duntley electric hammer drill. This is a tool suitable for drilling anchor-bolt holes in foundations and other similar services. It is operated by a motor which will work with either direct or alternating current, and the blow is applied to the tool by means of pneumatic transmission, with the object of preventing vibration being imparted to the electrical parts. The drill weighs only 21 lb.

TERRY STEAM TURBINES: ERRATUM.—Messrs. Fraser and Chalmers, Limited, inform us that they do not make, but only supply, the Terry steam turbines listed in their catalogue, which was noticed in our issue of November 24 last, page 519.

BLAST-FURNACE AND COKE-OVEN GAS.—Mixtures of cold blast-furnace gas and coke-oven gas have been utilised, but the suggestion to lead the blast-furnace gas directly into the coke-oven above the coke, so that the hot gases may react with one another, is probably novel. Experiments of this kind have recently been made by Dr. W. Zimmermann, of Worms, and the resulting gas, which he calls compound gas (Verbundgas) is said to differ in composition from the constituents, containing less carbon dioxide and free nitrogen, more hydrocarbons, both light and heavy, and more ammonia, and to be of higher calorific value. The addition of the blast-furnace gas, Dr. Zimmermann suggests, lowers the temperature in the coke-oven, so that the distillation takes place at a lower temperature, and less ammonia is decomposed. The experiments, described in *Stahl und Eisen*, of June 15, 1916, pages 573–581, were made in works in which an Otto oven was placed at Zimmermann's disposal; the gain in calorific power ranged from 6 to 13.6 per cent., the gain in ammonia amounted to 25 per cent. It would thus appear possible profitably to use a mixture of coke-oven gas and blast-furnace gas, prepared as indicated, in steel-making, and the consequent advantage would be important, especially near towns, where coke-oven gas can always be utilised. The additional gain of ammonia, as sulphate, would also be very welcome.

THE PRACHE AND BOUILLON EVAPORATING PLANTS.

CONSTRUCTED BY MESSRS. PRACHE AND BOUILLON, ENGINEERS, PARIS.

(*For Description, see Page* 637.)

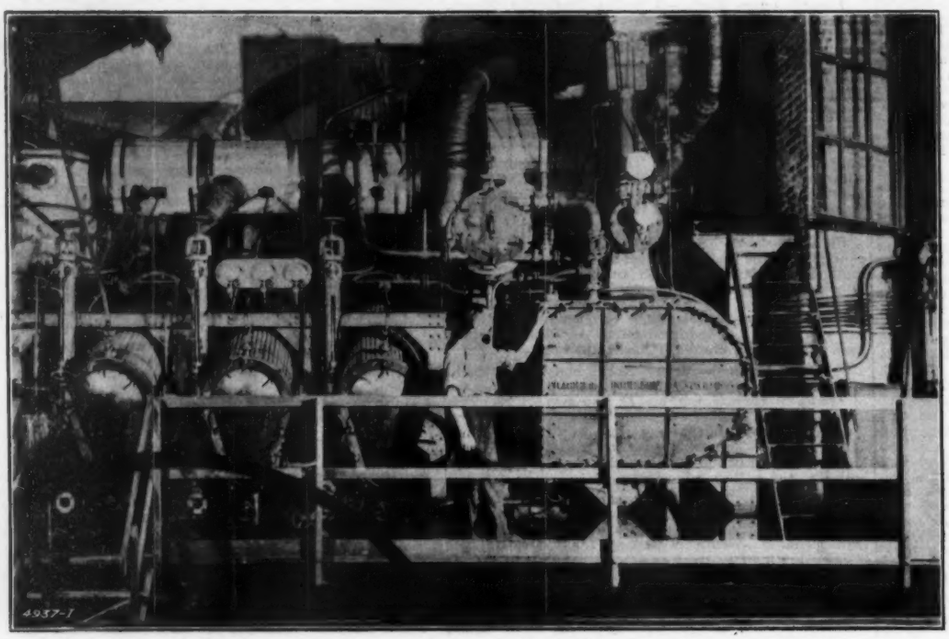


Fig. 9. Auto-Condenser with Multiple Effect Evaporators.

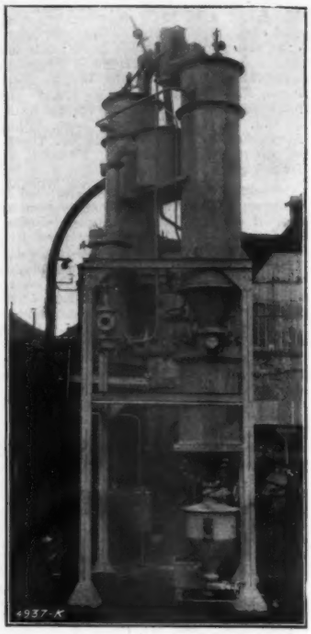


Fig. 10. Crystallising Evaporator.

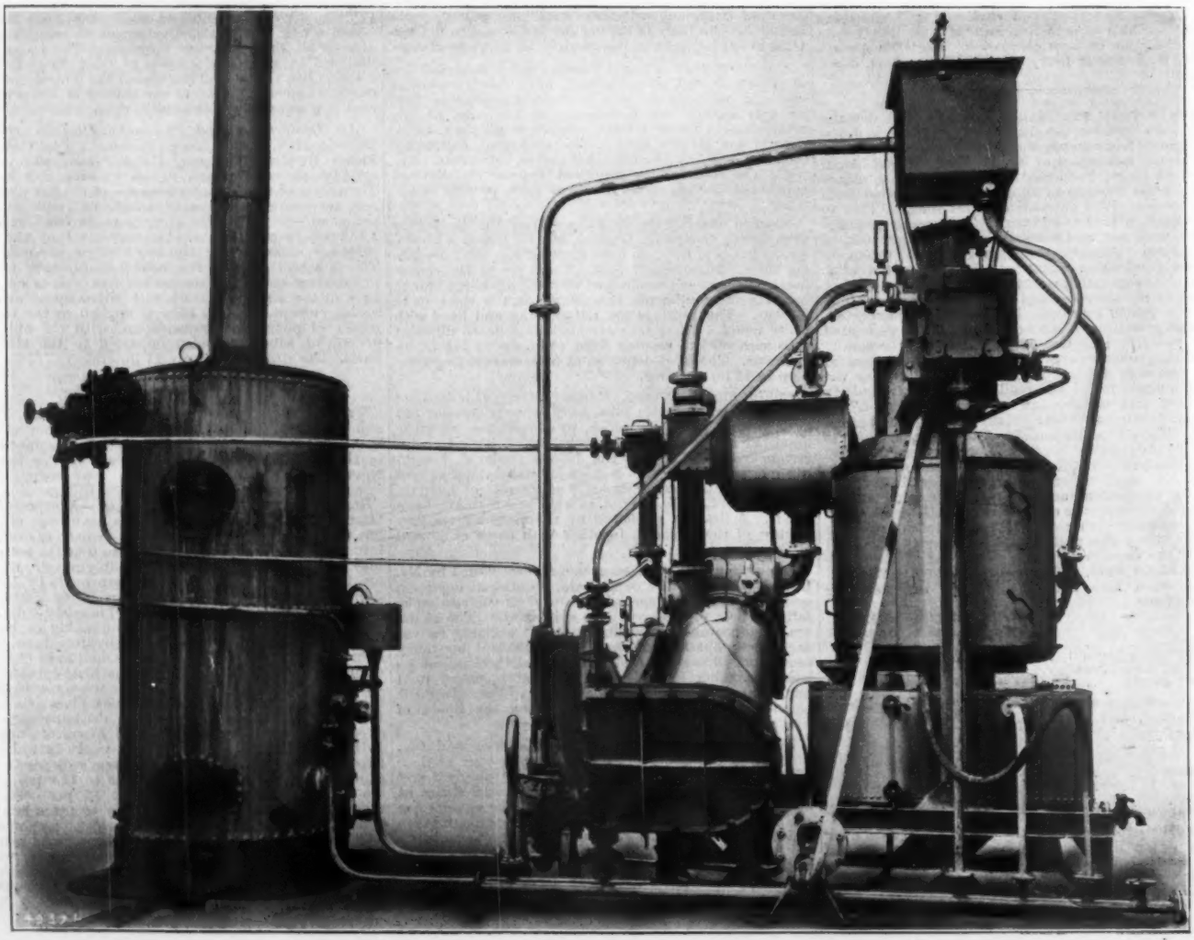


Fig. 11. Sea-Water Evaporating Plant for Small Outputs.

GEARED TURBINE INSTALLATION FOR SINGLE-SCREW CARGO SHIP, THE ELLERMAN LINER "CITY OF CANTON."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(*For Description, see Page* 636.)

Fig. 5.

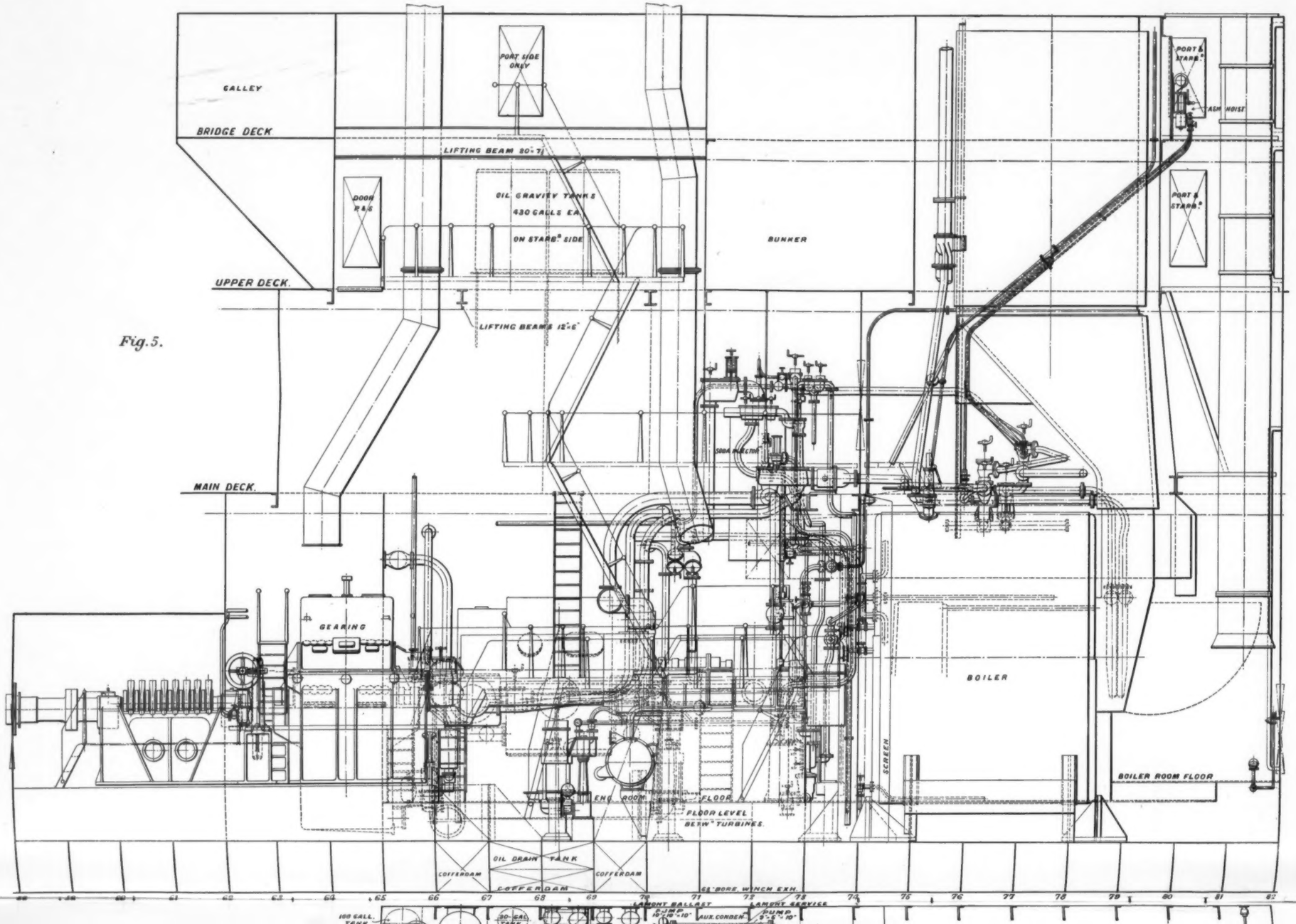
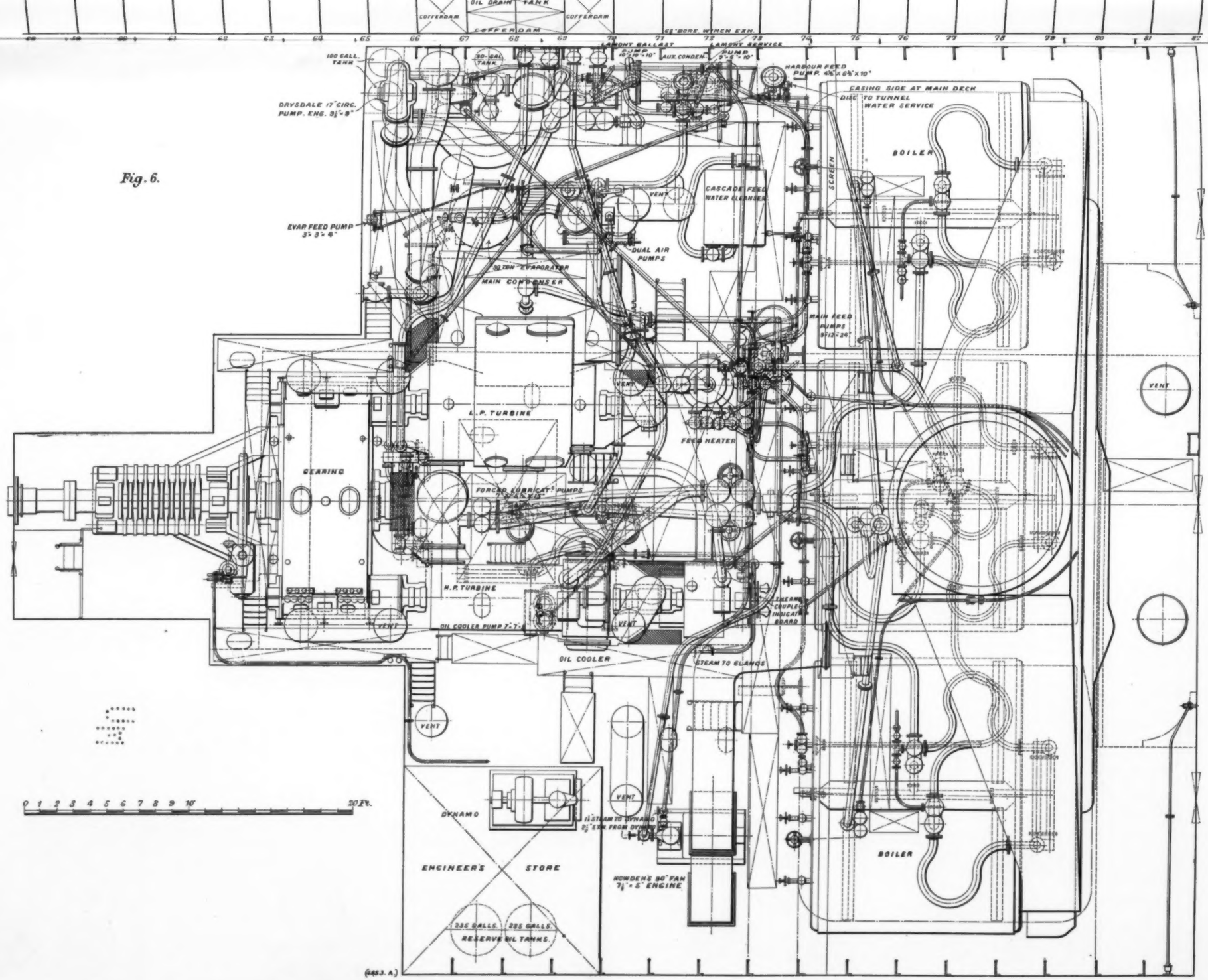


Fig. 6.


COFFERDAM
OIL DRAIN TANK
COFFERDAM
COFFERDAM
61" BORE WINCH EXH.
LAMONT BALLAST PUMP 10"-10"
AUX. CONDEN.
LAMONT SERVICE PUMP 8"-8"-10"
100 GALL. TANK
30-GAL. TANK
DRYSDALE 17" CIRC. PUMP. ENG. 8½"-8"
HARBOUR FEED PUMP 4⅝"x 6⅝"x 10"
CASING SIDE AT MAIN DECK
DISC TO TUNNEL WATER SERVICE
BOILER
SCREEN
CASCADE FEED WATER CLEANSER
VENT
EVAP FEED PUMP 3"-3"-4"
DUAL AIR PUMPS
30 TON EVAPORATOR
MAIN CONDENSER
MAIN FEED PUMPS 9"-12"-24"
L.P. TURBINE
FEED HEATER
GEARING
FORCED LUBRICAT? PUMPS
H.P. TURBINE
OIL COOLER PUMP 7"-7"-6"
OIL COOLER
STEAM TO GLANDS
DYNAMO
½" STEAM TO DYNAMO
½" EXH. FROM DYNAMO
ENGINEER'S STORE
HOWDEN'S 30" FAN 7½"-6" ENGINE
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RESERVE OIL TANKS.
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(6853. A.)

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The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3669 and 8598 GERRARD.

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With a Two-Page Plate of the GEARED-TURBINE INSTALLATION FOR SINGLE-SCREW CARGO SHIP THE ELLERMAN LINER "CITY OF CANTON."

NOTICES OF MEETINGS.

THE RÖNTGEN SOCIETY.—Tuesday, January 2, at 8.15 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. Paper by Mr. C. A. Schunk, "A Spectroscopic Investigation of Some Sources of Ultra-Violet Radiation in Relation to Treatment by Ultra-Violet Rays." Dr. Batten will describe a simple cross-thread frame for use in localisation.

THE INSTITUTION OF SANITARY ENGINEERS.—Wednesday, January 3, at Caxton Hall, Westminster, S.W., when the Presidential Address will be given. The retiring President, Mr. A. P. I. Cotterell, will take the chair at 7.30 p.m.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, DECEMBER 29, 1916.

COMMAND OF THE AIR.

AFTER nearly two and a half years of war we are about to appoint an Air Minister, and the result has only been attained by an agitation which has continued for months, most of it in a very intemperate fashion. Charges of incompetence and laxity have been flung at all connected with the Air Service, except the pilots and observers, very few of these allegations being deserved. The real cause of our difficulties lies much further back, in our national characteristics. Immediately after the appearance of the aeroplane we called attention in these columns, time after time, to the enormous change which it created in the methods of warfare—we pointed out that strategy had become at a bound vastly more difficult, and that the Napoleonic plan of hurling great masses of men at totally unexpected points could never again be successfully attempted by a force which had not full command of the air. As our army is essentially a small one it was of utmost importance that we should be possessed of every means of obtaining information to prevent it being entirely overwhelmed the first day it met a Continental force. There was no safeguard that could be proposed, in addition to the splendid training which the men had already received, that was so full of promise as a powerful aircraft service, which should supply our commanders with full information as to the movements of hostile troops and guard our own lines from all attempts at observation from above. Of course all this was perfectly well known to our military authorities, but when the Expeditionary Force went to France in August, 1914, we were only able to send 66 aeroplanes with it, and we had only 20 serviceable machines left in this country. If ever a people had cause for recrimination against its leaders we certainly had, were it not for the truth of the saying, "A nation has the Government it deserves." As a community we are always content to muddle through, and we cannot complain if we have to pay the price.

What has been the cost of our inability to hold the air as we hold the seas we shall never know. We have a general idea of the damage and bodily injury caused by the Zeppelin raids, which is marvellously small when we remember how completely we lay at their mercy for a long time, but what proportion of our losses at the front was due to the want of an adequate Air Service can never be ascertained. It must be remembered that an air fleet, like a naval fleet, needs to have command of its element if it is to be thoroughly useful. It is quite possible for a small army, by skilful manœuvres, to hold a much larger army in check for a long time, but a small fleet cannot sail the seas—or the air—unless it can accept every challenge and beat off its opponent. Ships may go commerce raiding against unarmed merchantmen and do immense damage, but there is no commerce in the air to be preyed upon. Half measures in the provision of aeroplanes are wasted effort, except as a step towards complete equipment.

As already stated, we started our campaign at the front with 66 machines. How many machines we have now must not be told, but we have four fronts, not reckoning our own shores, and at each of them Britannia rules the air, as she must continue to do in the future it we are to live in safety. When the first aeroplanes appeared there was a cry that England was no longer an island, and that the cause of her long-continued inviolability had ceased to exist. But, as we pointed out at the time, an island is by no means invulnerable. We have taken many of them—Malta and Jamaica, for instances—while India is practically an island as regards European attack. The safety of an island does not lie in the surrounding sea, but in the navy that sails it, and for the future our safety will depend largely on our aerial fleet. At the present moment our artillerymen on the Somme can sleep beside their guns in the assurance that they have not been spotted by any hostile aircraft, and that the shelling directed against them is only by guesswork. On the other hand, at our headquarters there are thousands of photographs taken over the enemies' lines, and from these complete maps of all the roads and trenches have been plotted. These maps are an answer to the great bulk of the charges which have been brought against the Air Service. We do not altogether regret that there has been an agitation, for however zealous officers and engineers may be they cannot go far beyond their instructions, and unless they have an active and bold civilian chief they may find it more difficult to convince him than to do the work they have in mind. Naturally each branch of our military service considers itself the most important and clamours for a large share of assistance. If money could solve all the problems the matter would be easy, but when it is a question of apportioning mechanics, materials and works to different objects the body that gets no aid from outside agitation is likely to be badly served. From this point of view the Air Service should have no cause to complain, as it has formed the subject of reference to several committees. We dealt with the report of the Committee on the Royal Aircraft Factory in our issue of August 4, and now we have the final report of the Committee on the Administration and Command of the Royal Flying Corps,* &c. The first report was not noticed in our columns. It was devoted solely to an investigation of the charges brought by Mr. Pemberton Billing against the control of the service. These proved in the main to be quite baseless, and such as were substantial could generally be shown to be the result of an excess of zeal in the pilots, or of taking risks which cannot be avoided in warfare, especially when it is entered upon unexpectedly. The final report traces carefully the causes of our defects and difficulties, and finally sums up the case as follows: "When we look back to the Royal Flying Corps at the outbreak of the war setting out with its 100 or so pilots, its 66 aeroplanes, for the front, and with its 20 serviceable ones at home for training, when we remember that none of its engines were of British design, and that it was dependent upon the goodwill of our Allies, the French, for much of its material, and when we see it now increased out of all recognition in numbers and efficiency of its aeroplanes, with their vastly improved engines, its ability to rely on British manufacturers to supply its needs, its training schools, its aerodromes, its equipment, its pilots and observers, its army of mechanics, it seems as though the Royal Flying Corps is a new creation. Our admiration is increased when we remember that all the work necessary to bring it into its present state of efficiency has been done while bearing the heavy burdens of rendering such services as the army required of it in the field and on the fronts. A microscopic examination has disclosed some mistakes, as we think. How could it be otherwise? General Henderson has told us that the responsibility is his for such shortcomings as there are. We ascribe them to the difficult position in which he was placed."

The committee included among its seven members the Hon. Sir Charles A. Parsons, F.R.S., and Mr. Charles Bright, M.Inst.C.E., so it was not dependent on expert testimony for an appreciation of the difficulties which the manufacture of new engines entailed. For the problem of aviation is largely dependent on engine construction. The Germans had pinned their faith to airships, and therefore

* Cd. 8194. London: Wyman and Sons. Price 3d.

had developed large engines, notably the Mercedes. We, on the other hand, had kept mainly to the aeroplane, and had only developed one type. Our sporting instincts had inclined us to the scouting plane, and as long as we had only small engines no other was possible. At the outbreak of the war the 80-h.p. engine was the largest available for us. Soon after there was the Canton-Unné (Salmson) of 140 h.p. These have since been discarded. The Royal Flying Corps also got out within the first few months of the war the 90-h.p. R.A.F. and the 120-h.p Beardmore. Later they obtained the 100-h.p. Monosoupape and the 110-h.p. Le Rhone, the latter in small quantities. Later still the 110-h.p. Clerget, but substantially the highest horse-power engine which the Royal Flying Corps had in quantity for many months was the 90-h.p. R.A.F. Quite recently it has had the 140-h.p. R.A.F., the 160-h.p. Beardmore, and the 250-h.p. Rolls-Royce. These are coming in, and there are other high-powered engines in sight, but the Flying Corps has, in effect, been carrying on with engines the bulk of which did not exceed 90 h.p., together with a few very efficient 100-h.p. to 120-h.p. engines.

The high-powered engines and big aeroplanes are wanted for other purposes than fighting. For long reconnaissance work, for weight carrying, for bombing, and for mounting large guns big machines are necessary. For fighting purposes what is wanted is a small, easily manœuvred, fast machine. At the beginning of the war we had only small machines, and zealous pilots would load them up with bombs and wireless plant, with the result that they were overburdened and fell a prey to the enemy. Now it is the practice to convoy the heavy machines, just as transports are defended by torpedo boats. Our chief difficulties in France arose in October, 1915, when the Germans brought forward their Fokker machines. These attacked our B.E. 2c machines, which were not so fast nor so handy, and could only do reconnaissance work if they were accompanied by fighting machines.

Fortunately our troubles are mainly in the past. The committee has made certain recommendations, of which the principal is that the equipment of the Royal Flying Corps should be entirely separated from the executive command and that the Royal Aircraft Factory should not become a manufacturing establishment. It has produced some unsatisfactory designs of aeroplanes, but, says the Report, "the R.A.F. exists to make experiments, and it is inevitable that some experiments must fail." There has certainly been a good deal of dissatisfaction in the trade about the R.A.F., but no one came forward to place his complaints before the committee, so it is probable the Factory furnished a target for every missile of irritability. The authorities there had a thankless task, anyway, for they were blamed if they did not press matters forward at all costs, and they were also blamed if they did not achieve perfection at the first attempt. They had also to deal with many manufacturers who had no previous experience with aeroplanes and had to be watched most carefully. On the other hand, there were other manufacturers who needed no instruction, and indeed were more fitted to instruct than to learn. Such diversities of practice do not fit in well with Government control, and give rise to complaints which are inevitable. However, in spite of all these difficulties we have achieved the command of the air, and the credit may be fairly divided among the Royal Flying Corps, the Royal Aircraft Factory and the engineers of the country. There is enough for each to be satisfied, and while a very large proportion is due to individual manufacturing engineers, these escape the criticism which is directed towards the official bodies. The advance in engine construction has been very largely due to the engineering firms of the country, and as the aerial service is dependent for its efficiency upon the engines, it follows that our manufacturing engineers can justly take a large share of the credit to themselves.

TRADE PROSPECTS AFTER THE WAR.

It is being laid down very definitely by certain authorities that trade will be very depressed for a long time after the war. Without directly challenging these authorities, we may venture to call attention to facts and circumstances that afford ground for the opinion that trade will be exceedingly good for at least a few years after the war. Much, however, depends upon the policy we adopt. If our statesmen go on heavily taxing and regulating and harassing productive industry and enterprise, and will not afford any protection or encouragement for wealth production, and if labour continues to demand high wages without yielding a full output, then British trade will most certainly suffer not merely a long-drawn-out depression, but permanent decay, although the world's trade may expand enormously. We believe that the world's trade will be good after the war, certainly the trade of some countries will be excellent; but whether British trade proves bad, good, or excellent, will depend upon British methods. The coming trade war, as it is termed, will only be won by hard work, as the present war will only be won by hard fighting. The largest share of the world's trade will go to the nation that produces the most goods at the least cost.

In weighing up the possibilities of future trade—and our plans must depend largely upon what we anticipate—certain cardinal facts must be kept in mind. Among these facts the most important is that agriculture is still the world's most important industry. Directly and indirectly, the farmer has more to do with the condition of the world's trade than any other man. Taking the world through, millions more people are engaged in agriculture than in any other industry or group of industries. In other words, the demand for manufactures—for clothing, furniture, utensils, tools, implements, wagons and cars, and even railways and ships—comes more from the farming class than any other. The farmers of the world are enjoying unparalleled prosperity; therefore, when the war is over, and the prices of manufactured goods fall to anything approaching normal levels, the agricultural classes will call for unprecedented quantities of manufactures. There will also be great railway extensions in most of the great food-producing countries, while our shipyards, we may be sure, will be kept busy for at least a few years making good the war wastage and the arrears of merchant building that have accumulated whilst the demand for war vessels and repairs has been abnormal. In practically every line of ordinary business stocks of manufactures are running low, and many people are putting off, as far as they can, renewals and repairs and new purchases until the war is over, when they hope that prices will be lower. For these reasons it seems certain that for some years after the war the world's general demand for manufactures will be greater than it was before the war, in spite of a continuance of comparatively high prices and the shortage of money.

Another important fact that should be observed is that, in the main, the world depends upon three countries for the bulk of its manufactures—the United States, Germany and Britain. These three nations, between them, produce not less than about 70 per cent. of the world's iron, steel, engineering, textile and general manufactures. These three nations, therefore, will stand to share the great bulk of the world's business in manufactures, and Britain's share should be the biggest.

The next point to which we would draw attention is the probability that Germany will obtain a smaller proportion of the world's trade after the war than she did before, leaving larger proportions for America and Britain. As a penalty for plunging Europe into war Germany will pay dearly in men, money and trade. Her colossal losses in men, killed and incapacitated, will seriously weaken her productive and competitive powers. Our smaller losses of man-power will probably be more than balanced, measured in terms of industrial production, by improvements and speeding up of machinery, by the extension of works, and by women's labour. It is difficult to see how Germany can make good her huge loss of man-power.

Another point in the trade problem is the question of export subsidisation. Before the war the German Government, banks and syndicates specially subsidised and in other ways assisted the exporters. It was not really cheap production so much as subsidisation that enabled the Germans to build up such a large foreign business and become our chief competitors. The Government not only protected producers from outside competition by tariffs, but it carried goods for export on its railways at half the ordinary rates, and it paid subventions to German ships carrying German products to foreign markets. The German banks, as is well known, granted positively lavish assistance to manufacturers engaged in export trade, while the syndicates worked a really wonderful system of export bounties. It is probable that the war will leave German finances so depleted that nothing like the pre-war methods of subsidising exportation can be renewed. Without subsidies and bounties German competition cannot be conducted with the old keenness. Besides, the Allied Powers may be able to take some practical measures to prevent, or check, what is called dumping—that is the selling of goods abroad below natural prices by means of subsidies and bounties.

Then there is the question of boycotting, or specially penalising, German goods. It may not be either possible or desirable to shut out German products entirely; but this war is going to leave some deep impressions on our minds, and it will prompt the Allied Governments to adopt some discriminatory measures against enemy trade. To the nations with which Germany is at war she was selling 400,000,000*l.* worth of goods a year before the war. She has hit and seriously offended and disgusted nearly all her best customers. With millions of people refusing, as far as possible, to purchase German goods, with the Allied Powers adopting discriminatory tariffs, and with our Colonies and Allies giving us practical trading preferences, we are bound to secure much trade that would have gone to the Germans, had it not been for this German-provoked war, providing, of course, that we do not destroy our chances by relapsing into our pre-war slackness.

Regarding American competition it is probable that the United States will enjoy advantages as a result of the weakening of German competition, the high prices that will prevail in this country, and the big world's demand for manufactures. We believe that, with our Government adopting a sane attitude towards trade and industry, and with labour and capital working together on anything approaching good terms, our productive capacity will be fully employed with the overflow of orders going to America. In the United States wages and other costs are so high that we need not fear any severe price-cutting competition from that quarter. The Americans will only take export business at high prices. If the war results in ridding us of that particular form of German competition we found so detrimental to our interests before the war, and if we can secure reasonable co-operation between labour and capital, and between industry and the State, our economic future will be assured. There will be an abundance of trade in those goods we are specially competent to produce.

CARBON-TUBE FURNACE FOR TESTING REFRACTORIES.

During the recent discussion on refractory materials in the Faraday Society, Mr. Ezer Griffiths, M.Sc.,* referred to the work done at the National Physical Laboratory. He supplemented his communication in the meeting of the same Society held on Monday, the 18th inst., when he described and exhibited, in conjunction with his brother, Mr. E. A. Griffiths, a "New Electric Furnace for Testing the Softening Points and Compressive Strengths of Refractory Materials." At this meeting several other papers were read. We shall deal with one by Messrs. Parker and Dalladay, on a "Precision Method of Uniting Optical Glass," in a future issue. A theoretical paper by Professor W. C. McCullagh Lewis, D.Sc., of Liverpool, on "The Effect of Pressure on the Equilibrium Constant of a Reaction in a Dilute Solution," likewise came up for discussion, and Sir Robert Hadfield, the President of the Society, communicated two papers on steel, one by Professor E. D. Campbell, of Michigan University, on the question: "Do Equiatomic Solutions in Iron Possess Equal Resistances?" and the other by Mr. Ralph H. Sherry, M.A., of Detroit, on "Grain

* See Engineering, page 489 *ante*.

Growth in Deformed and Annealed Low-Carbon Steel." We reserve notice of these two steel papers, and pass to a description of the electric furnace.

In order to test the softening point and compressive strength under load of refractory materials, Mr. Ezer Griffiths explained, carbon tubes were required bearing temperatures above 1,800 deg. C. Their furnace, a view of which is shown in Fig. 1, while Figs. 2 to 6 illustrate details, contained, within a sheet-iron casing, 12 in. in diameter, closed by two diaphragms B B (Fig. 2) of asbestos slate, the carbon tube C, 2 and 1½ in. outside and inside diameters, 11 in. long. To admit of temperature observations on the specimen, nearly the whole length of the tube was slotted, the slot width being ¼ in.; a slot and not a round hole was made, not to produce a discontinuity in the electric resistance of the tube. The tube was packed with crude zirconia, *i.e.*, powder of the mineral baddeleyite (about 75 per cent.

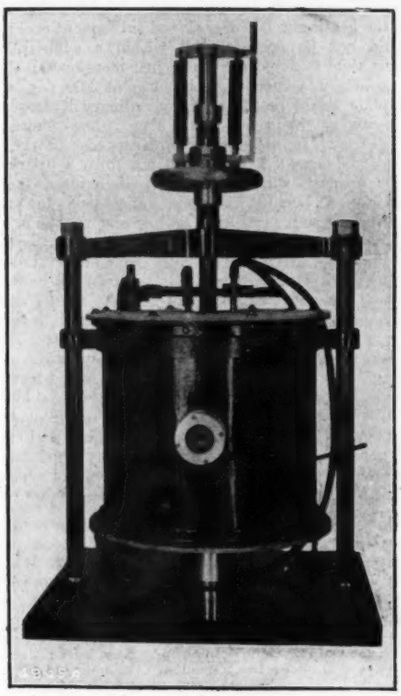


FIG. 1.

of ZrO_2, 13 of SiO_2); this zirconia began to frit at about 1,100 deg. C., and would, in contact with carbon, form a carbide, sintering to a solid tube around the carbon. To avoid this carbide formation a layer of electrically-shrunk magnesia was inserted between the carbon and zirconia. Outside the zirconia was a layer of magnesia-asbestos lagging. The pressure was applied by means of a plunger arrangement. Two equal springs were attached to the ends of the cross-bar D and the collar E; the latter could be screwed up and down the fixed tube F by the aid of the hand wheel G, rotation of the springs being prevented by the keyway in F. The pressure, up to 150 lb. per square inch, was measured on the scale H, and the whole arrangement was carried on the cross-bar K, which could be swung round one of the furnace pillars, in order to obtain access to the furnace. The specimen was applied in the shape of a cylindrical rod, usually 1 in. long, ⅝ in. in diameter; when a brick was to be tested, a piece was chipped off and ground to the desired shape. The specimen was placed between two carbon rods, which had not given any trouble from breakages; when necessary, distance pieces of tungsten were interposed to avoid contact between the carbon and the refractory material. The metal parts were made of aluminium containing 20 parts of zinc and 6 of copper.

The construction of the electrodes, which have to bear heavy currents, will be understood from Figs. 3 and 4. Two copper tubes (Fig. 4) were bent into a zigzag form, and white bearing metal was cast round the tubes, the mould being formed of strip iron, with the carbon tube as core. The casting thus obtained, Mr. Griffiths explained, would exactly fit on the carbon tube with its bearing surface, without there being any need for machining the metal faces or grinding the end of the tube, expedients resorted to in earlier types of furnaces. The copper tubes protruded loosely through holes in the cover B (Fig. 2), and the carbon tube could hence expand without straining any parts. With a current of about 400 amperes through the tube, the drop of potential across the contact was less than 0.1 volt. As it was almost impossible to obtain carbon tubes of exactly the same diameter or of absolutely circular cross-section, a few sheets of tinfoil could be inserted between the electrode and tube to distribute the pressure. The electrode construction, illustrated in Figs. 5 and 6, was designed for a large 5½-in. crucible furnace. The

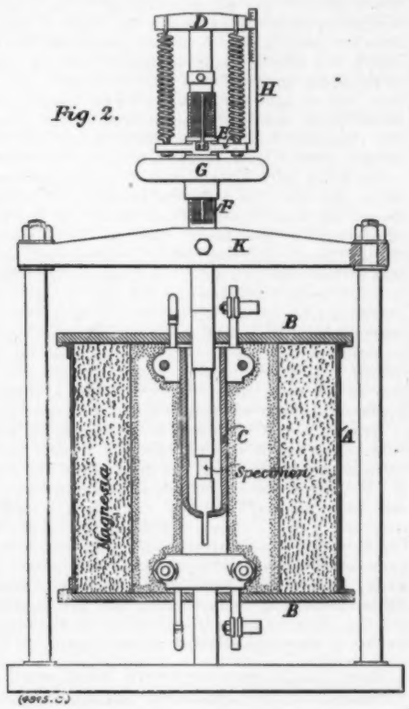


Fig. 2.

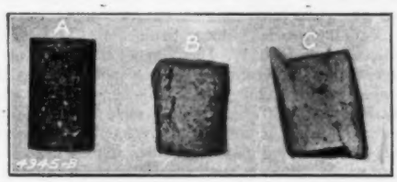


FIG. 7.

two blocks of graphite L L″ were bored to the external diameter of the carbon tube. The current entered through the water-cooled copper tube M, which was soldered to the copper strip N; to reduce the current density a second current lead was provided by the flexible strip of copper O which was bolted to the block L″. During the observations nitrogen was passed through the carbon tube, lest the carbon be burned; a neutral atmosphere of nitrogen was preferable to one of hydrogen, because the hydrogen diffused through the hot walls. Contamination by volatile carbon compounds was not to be feared below 1,700 deg. C.; pure iron melted in a magnesia crucible within a carbon furnace did not absorb carbon at 1,600 deg. and slightly above; but when the temperature reached 2,000 deg. contamination by carbon vapours was inevitable. Material particles, probably molecular aggregates, were, moreover, shot off from the carbon at high temperatures, and strong ionisation currents passed through the ionised atmosphere from the hot tube to cooler parts.* When a water-cooled tube was placed axially inside the hot carbon tube, negative currents of up to 0.8 ampere had been observed by Mr. Griffiths (no external electromotive force being applied), and the cold tube became covered with a thick deposit of carbon, sufficiently coherent to be slid off in short lengths. This reason limited the use of carbon-tube furnaces at temperatures above 1,700 deg. C., though they would yield and stand temperatures of 3,000 deg. for short periods. Most refractory materials softened under load at temperatures below 1,700 deg. C.

Current was obtained from a rotary converter and transformer. Temperatures were measured by the aid of a polarising type of optical pyrometer, the sighting on the specimen being slightly oblique so as to avoid slight errors possibly arising because the temperature of the side of the specimen in direct

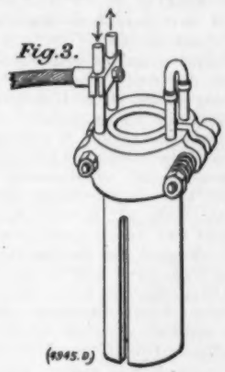


Fig. 3.

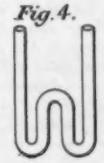


Fig. 4.

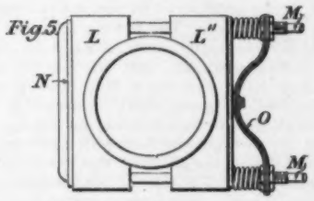


Fig. 5.

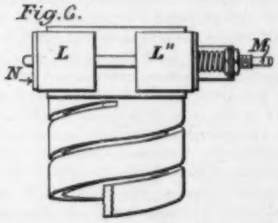


Fig. 6.

line with the window might be lowered by radiation. Two adjacent fields were matched in the observations; the one field was that of the object, the other that of an electric lamp through which a constant current was flowing; observations could be repeated without difficulty, within 10 deg. at 1,500 deg. The instrument was calibrated by comparison with a thermo-couple under black-body condition, the couple being standardised by the aid of the freezing-points of gold, 1,063 deg., copper, 1,083 deg. (reducing atmosphere), nickel, 1,452 deg. (neutral atmosphere), palladium, 1,549 deg. C. A test lasted about 2½ hours. The specimen was placed in position in the cold furnace, usually under a pressure of 30 lb. per square inch, and the temperature was raised; higher pressures were applied if desired. At least three specimens were tested in each case, and the results were fairly concordant. Fig. 7 shows a specimen cylinder A, and specimens of two magnesite bricks, fired at different temperatures; B had failed at 1,500 deg., C at 1,330 deg. C., both under pressures of 30 lb. per square inch.

Mr. Griffiths was not unprepared to hear questions as to the advisability of using small specimens—he stated that he could double the diameter—specially prepared by grinding and placed between

* We have noticed these researches by Drs. Harker and Kaye on previous occasions.

rods which might not exert normal pressure, points raised by Dr. Rosenhain, Dr. Lessing and others. So far as possible, one fancies, bricks should be tested as used, with their kiln skin on; the grinding might particularly affect the coarse-grained material in small specimens. Large specimens have been tested as they are, by Bleininger and by Mellor; then, however, other difficulties, concerning uniformity of temperature, &c., arise. Mr. H. M. Ridge referred to the fixing, by the authorities, of maximum prices for refractory materials. The result of this regulation had been that prices had been raised, and that maximum prices were demanded for materials which were not superior, whilst the authorities were not yet prepared to regulate prices on the basis of quality tests. There is much to be done yet, of course, as to refractory materials; but the societies interested in the matter are taking joint action.

NOTES.

Liquid Pitch from the Still for Briquette-making.

A big plant for briquette-making with the aid of the hot, liquid pitch, delivered by rail direct from the tar works, is being erected at the Hohenzollern colliery near Beuthen, in Upper Silesia, which belongs to the estates of the Counts of Schaffgott. The novelty is the use of the liquid pitch transported in special tank-wagons by rail. This novelty was tried first in August, 1914, in the Essen district, when ordinary boiler tanks of 15 tons capacity were used; the tanks had only 3 miles to travel by road, but with charging and discharging the tanks the operations took seven hours; yet there was a saving in material and cost. For the plant now being completed in Silesia, the State railway line is to be utilised, and the consent of the Government had first to be obtained for the transport of the liquid pitch. The consent was readily granted, subject to the addition of certain safety appliances to the tank-wagons. The process adopted is that of Fohr-Kleinschmidt which, worked on the old plan, starting with dry, cold pitch to be melted, was a little more economical than other processes, but promises a considerably increased economy when starting with liquid pitch on the new plan. In 1913 we see from the *Zeitschrift für angewandte Chemie*, of September 26, 1916, there were produced in Germany 5,823,776 tons of coal briquettes (not including lignite briquettes), containing about 400,000 tons of pitch—7 per cent. on an average. Different briquette processes required from 5 to 9 per cent. of pitch, and the prices were, before the war: lignite briquettes, 1.10 mark; coal briquettes, 2.50 to 3 marks; pitch, 5 marks, each per 100 kg. It might be thought that liquid pitch and powdered or disintegrated coal might be run directly together in briquetting; but such attempts only yield a lumpy product devoid of strength. By the Fohr-Kleinschmidt process the cold pitch as supplied, without fine disintegration, is heated first to 100 deg. C.; the thick fluid is then transferred to a melting drum kept at 130 to 170 deg., from which the thin liquid flows into a receptacle to be further heated and sprayed by means of steam or compressed air. The sprayed particles congeal in a mixing drum, while still floating in the air; in this condition the pitch, forming a sooty dust, meets the finely-disintegrated coal and is mixed with it in slowly-revolving drums, which are fitted with stirring and lifting devices. The mixture passes into kneading apparatus and is pressed into briquettes at temperatures ranging from 50 to 80 deg. C. There were difficulties to be overcome, of course, in this process; but the Engelsburg colliery of the Verein für Bergbau und Stahlindustrie at Bochum has eight presses at work, yielding some 600 or 700 tons of briquettes daily. The pitch consumption has been reduced by 1 per cent. by the adoption of the Fohr-Kleinschmidt process, and the hot pitch is to make a further reduction in the cost possible, as we mentioned. There will be less waste, no need for disintegrating and remelting the pitch, and several operations will be much simplified; the disintegration affected the eyes of the men in charge, moreover. The emptying of the tanks by compressed air takes 15 minutes. The pitch to be used in the new plant in Silesia is distilled at a temperature of 250 deg. C. Softer pitch containing tar oils would be suitable for briquette-making; but tar oils cannot be spared at present; the price of pitch was 50 marks in Germany last summer, instead of 5 marks before the war.

The Bursting of Household Water Pipes.

We were not aware that the hot water pipes leading from the furnace to the kitchen and bathroom are considered much more liable to burst when freezing than the pipes through which only cold water is flowing. But burst water pipes are fortunately not very common in our climate. In America, we see from a contribution by Mr. F. C. Brown to the *Physical Review* of last November, plumbers are quite acquainted with this peculiarity. In investigating the problem Brown did not quite imitate the actual conditions. Instead of taking long iron pipes, open at both ends, he took short glass tubes of various sizes, generally about 1 cm. in diameter, closed at one end. The difference in the conditions was not essential, probably. Anyhow, filling glass tubes with cold tap water, as taken from the mains, and with the same water previously boiled, and placing them alternately side by side in the open, he found that after intervals ranging from half an hour to four hours a good many tubes would burst, and it was predominantly the tubes that contained boiled water which broke. Out of 50 pairs of tubes tried, 44 which burst had contained boiled water, only 4 burst tubes contained unboiled water, and more than half of the tubes did not break, though all were frozen. From these and further experiments it was found that the boiled water did not freeze until considerably undercooled, and that it then froze to a solid, clear mass of ice. The unboiled water began freezing at 0 deg. C., and the ice showed a core of air bubbles, as in cakes of artificial ice. No doubt the air bubbles facilitate crystallisation and, separating out when the water freezes, take up the pressure of the expanding ice; the ice in these cases, moreover, had a slushy appearance, and it was known from the experiments of Quincke and of Koch that ice containing air and salts is less elastic and mechanically weaker than ice from pure boiled water. In his researches on ice, H. T. Barnes passed chilled air through water, and then obtained a slushy ice lacking in solid structure. When Brown saturated water which had been boiled with air, the tubes did not burst more readily than tubes charged with unboiled water. The presence of a slight percentage of salts did not seem of any importance; it is well known, of course, that the water freezes out of salt solutions, leaving a more concentrated mother liquor.

Radium α Rays and Active Hydrogen.

Though α rays are known to decompose water and to ozonise oxygen, most attempts to utilise the rays for what is designated the "activation" of elements have so far failed. In the *Physical Review* of last June Drs. W. Duane and G. L. Wendt describe some successful experiments with hydrogen, however. Activation means the conversion or splitting up of the free hydrogen molecule into two atoms or some modification which is much more active than the original molecule. Great care is, of course, required in such researches. Duane and Wendt prepared their hydrogen by the electrolysis of diluted hydrochloric acid with the aid of platinum cathodes and anodes of pure amalgamated zinc, the latter binding the chlorine liberated as chloride. The hydrogen was passed through caustic potash, over red-hot platinised asbestos, and over lumps of potash and phosphoric anhydride to remove all traces of acid, water, chlorine, oxygen and carbon dioxide, also any arseniuretted hydrogen present; it was found, however, that the hydrogen generated was not contaminated with arsenic even when the zinc was not free from this common impurity. When a bulb of 5 cub. cm. capacity, filled with the pure hydrogen, was exposed to the radiations from 35 millicuries of emanation, a slight diminution of volume was observed in the mercury gauge joined to the bulb, the gauge being in communication on the other side with a bulb containing the same hydrogen, not radiated upon. This diminution would indicate, not a dissociation, but an association of hydrogen molecules, unless due to some effect of the rays on the mercury. In the further experiments the hydrogen was exposed to the rays while flowing through a bulb into a large tube containing flowers of sulphur. Ordinary hydrogen does not attack sulphur in the cold. The hydrogen exposed to the α rays did indicate some formation of H_2S after five or six hours; the quantity was very small, however, less than one milligramme. The active hydrogen, moreover, was very unstable; when more than one minute intervened between the radiation and the contact with the sulphur, the chemical effect observed was very feeble or absent; in check experiments no effect whatever was observed. When the hydrogen was sent through a long coil immersed in liquid air before radiation the effect was not impaired; but when the cooling took place after the hydrogen had been radiated upon, the activity was destroyed. This might be due to a condensation of the active hydrogen on the inner walls of the glass coil, if not simply due to the fact that the time taken up by the flow through the coil favoured the return to the inactive state. Whether or not heat would destroy the activity could not be determined, as the heating to 600 deg. C. and subsequent cooling could not be accomplished within a sufficiently short time to avoid the decay just mentioned; the recooling was necessary because at 200 deg. C. sulphur would be attacked by ordinary hydrogen. The active hydrogen had also other unusual properties. It attacked phosphorus and the grey powdered arsenic; but it did not form a hydride with bismuth, which would have been interesting, because a bismuth hydride (analogous to the hydrogen compounds with arsenic and phosphorus) is not yet known. With mercury the active hydrogen yielded a bright yellow compound; it also reduced permanganate solution, but failed to reduce several organic colouring matters like indigo and carmine. The atomic mechanism of this activation is not yet understood. In many cases activation means dissociation of the molecule into atoms or ionisation. When the active hydrogen was directly passed through an electric field, however, in which a separation of the ions should have taken place, it remained unaltered. It would have been particularly instructive to ascertain whether any compound like the H_3 would be formed, the existence of which Sir J. J. Thomson assumes from his researches on X-ray analysis.

LITERATURE.

Geodetic Surveying. By Edward R. Cary, C.E., Professor of Railroad Engineering and Geodesy, Rensselaer Polytechnic Institute. New York: John Wiley and Sons, Inc.; London, Chapman and Hall, Limited. [Price 10*s.* 6*d.* net.]

Books on surveying, of which several have appeared of late, usually treat of small areas, in which the spherical figure of the earth is negligible, and the problems of geodesy involving more precise methods and requiring a knowledge of the geographic or geocentric positions of points on the earth's surface do not occur. The author addresses here a more specialised class, and one which generally receives its training under skilled professional guidance. The instruments used are of a delicate and costly construction, such as are found only in the hands of trained observers. The methods for conducting such surveys, sanctioned by long experience after severe tests, are described in special treatises only to be unearthed and translated by experts, trained in the traditions of the service. Mr. Cary is familiar with the methods of the United States Coast and Geodetic Survey, has access to their recondite publications, and by exhibiting in detail the processes that have been evolved, accomplishes two useful purposes. He explains to his countrymen the nature of the important work on which a Government Department, and one entailing a not inconsiderable expenditure, is employed and, also, by indicating the degree of accuracy that can be attained by the most judicious use of instruments, he may set a higher standard than usually obtains in commercial surveying. We should imagine that these were the objects of the author rather than to teach students the rigorous methods practised in the Coast Survey.

The work of the department is extensive. It embraces the determination of the geographical position of stations by means of astronomical and

geodetic methods, hydrographic surveys along a coast that, including islands and indentations, has a length of not less than 100,000 miles, topographic surveys of a strip of land 3 or 4 miles wide throughout this same length, and the construction of a network of precise levels covering the area of the United States. There are other duties connected with the study of terrestrial magnetism and variation in the force of gravity, not less onerous and time-consuming, but since the methods involved or the results attained do not come before us in this volume, no further mention of these is needed.

The United States Coast Survey has been in operation more than a century, and considering the time during which accurate globe measurement has been pursued both in Europe and America by every civilised government, it may surprise the lay mind to learn that any considerable portion of the earth's surface remains unexplored. That far more remains to be achieved than has been already accomplished should convey a feeble notion of the labour involved in constructing an accurate map of a country or district, to say nothing of combining the many results made under various conditions into a systematic and coherent whole. Mr. Cary claims that the work of the United States Coast and Geodetic Survey furnishes the most valuable data for the determination of the figure of the earth that have been contributed by any one nation. Without more precise information we are not prepared to dispute this statement, but remembering what we have accomplished at home, in India, in Africa, and elsewhere, we think our own contribution to the necessary work of investigation falls but little behind. But any pride that a nation is inclined to exhibit in its scientific activity in this matter is severely chastened when confronted with a map of the world, that shows what has been achieved and what remains to be done. Naturally those portions that are inhabited by the most advanced nations have been most accurately surveyed, but at present even those portions do not amount to more than about one-seventh of the whole land surface, or are about equal in extent to that other portion which, on account of sparseness of population or difficulty of access, remains entirely unsurveyed and unmapped. About one-twelfth of the globe is known with some completeness from fairly trustworthy surveys, not of the highest order of accuracy, and chiefly non-topographical, while finally the great mass of the earth's land surface, about two-thirds of the whole, is only known from route traverses and sketches. There remains, therefore, very much more work to be done, and judging from the rate of progress in the past, it is computed that 400 years would be required to complete the work with the care that is now bestowed on the best determinations. But as every year shows an accelerated rate of improvement, the outlook is not quite so bad as these figures imply.

Mr. Cary should have a large and attentive audience as he unfolds a scheme which is well adapted for accurate trigonometric surveying. But we are afraid that he will meet with very little attention, because, as we have hinted, the professional classes have their own literature, and commercial circles will hardly welcome a work that aims at a degree of accuracy demanding more time and a heavier expenditure than the methods in ordinary use.

Neglect, however, does not necessarily imply a want of merit, and though this may not be the up-to-date English text-book that is sorely needed, it goes a long way towards supplying the want. Starting from a description of the machinery and of the general principles employed in carrying out a reconnaisance survey, the author describes the measurement of a base line with the refinements necessary for accuracy. We have been so accustomed to the measurement by chain, or perhaps the still less accurate method by tacheometric devices being recommended as sufficient, that it is refreshing, as it is novel, to find a good account of lineal measurement based on the 50-m. invar tape. These tapes can be used with a rapidity and accuracy that should ensure them a more general use. They are approximately 6.3 mm. wide, 0.5 mm. thick, and weigh 25 grammes per metre, slightly heavier than steel. The tensile strength is only about one-half that of steel, calling for more care in use, especially as the elasticity is less. Small bends may be noticeable when the tape is not stretched, but under a pull of 15 kg. those bends are so nearly eliminated that continued stretching does not affect the length of the tape. If these be regarded as drawbacks, they are amply outweighed by the reduction of the trouble due to change of temperature. An error of 2.5 deg. in temperature on the invar tape produces only the same error in the measurement as an error of 0.1 on the steel. An accuracy expressed in millionths of the length measured is not to be attained by simply reading off the tape, however constant its length, several corrections have to be made. These are satisfactorily explained. Usually the tape is supported on stakes about 12 m. apart, giving to the curve between the stakes the form of a catenary, and require a correction for "sag" to reduce the measured length to a straight line. There will also be a correction for stretch, since the length will vary proportionately to the pull, and a "grade" correction, a consequence of the supports of the tape not being in the same horizontal line owing to the irregular nature of the surface over which the base line is run.

These corrections are developed in considerable detail and the probable error is stated, but the method of working might be shown more clearly. A base of 13,191 m. has a probable error of 5.15 mm., corresponding to a precision of 1 in 2,561,000. The cost of measurement was 147 dols. per mile. In another case, in which the precision was not quite so high, the cost was 116 dols. per mile. With steel tapes the cost is from 20 to 30 per cent. higher. The saving is mainly due to the more rapid manner in which the work was effected, no loss being occasioned by bright sunny weather causing frequent changes in temperature.

The measurement of horizontal angles, with the necessary corrections and final adjustments, or closing errors in polygons, is described with equal thoroughness, and should give a very good notion of the character of work on an ordnance survey. This concludes the method of delineation of areas, and not inappropriately a chapter is introduced on projections and map-making, as severely practical as the preceding portions.

The methods of observing differences of level are developed with the same care as in triangulation, the limitations in the different methods of levelling being clearly insisted upon, as are the circumstances under which each method may be adopted. In the measurement of vertical angles atmospheric refraction is necessarily a troublesome subject that theoretically or practically leaves a certain amount of dissatisfaction. The value of the section on trigonometrical levelling is that it explains the methods that have been adopted by the Coast and Geodetic Survey. Its practical utility is demonstrated by the summing up, which we presume applies to a mountainous country, where angular levelling is best adapted and the cost of precise levelling becomes prohibitive. "The probable errors of the elevations found from reciprocal readings of the vertical angles vary from ± 0.1 to ± 0.9 m., and for elevations of intersection stations the probable errors may be as large as ± 3 m. In precise levelling carried out with the dumpy level these probable errors are of course much reduced. In a single kilometre of completed levelling the average probable error amounts to ± 0.7 mm. The probable error of a single kilometre of completed levelling derived from the adjustment of the level net is ±0.67 mm. This is the evidence from the level net as a whole." In this accurate work the average rate of progress is 69.5 miles of completed line per month, and the cost per mile is 11.10 dols. Six thousand miles have been completed between 1907–12.

If the observations procured at so much care and cost are to be used for the determination of the figure of the earth, it is necessary to connect the results of the triangulation with the longitude and latitude of stations on the earth's surface. The determination of these co-ordinates the author describes as more the work of an astronomer than of a surveyor, and banishes the procedure to an appendix. In accuracy, as in completeness of description, this portion falls below that of the body of the book. It leaves the impression that while the author has been actively engaged in the practical work of surveying, he has not taken personal part in the astronomical observations. The adjustment of the transit circle might be rewritten with advantage. The Horrebow–Talcott method for finding the latitude is mentioned rather than described, and the real difficulties of determining the latitude with the accuracy needed for geodetic measurements are not seriously faced. Similarly the chapter on the Method of Least Squares exhibits the kind of fault which is sometimes described, but often unjustly, as amateurish. Nowhere are the severe methods of professional work suggested, and this lack of thoroughness is the more remarkable, as some well-known American works provide an excellent example. But the book under notice is particularly welcome as indicating the existence of a school of geodesy in America, training men to combine an adequate knowledge of mathematics and physics with practical experience of observing work. In this country, apparently, we fail to appreciate the need of such combinations in the work of advanced education.

BOOKS RECEIVED.

Le Commerce Allemand : Apparences et Réalités. By DANIEL BELLET. Paris : Plon-Nourrit and Cie., 8, Rue Garancière. [Price 3 francs 50 cents.]

Dynamical Stability of Aeroplanes. By JEROME C. HUNSAKER, ENG.D., Assistant Naval Constructor, U.S. Navy. Washington : Published by the Smithsonian Institution.

Lectures on Levelling. A Practical Course of Instruction. By V. J. MARTIN, M.Sc. (Victoria), ASSOC.M.INST.C.E. Singapore : Kelly and Walsh, Limited.

Annual Report of the Department of City Transit of the City of Philadelphia for the year ending December 31, 1915. Philadelphia : Issued by the City.

Le Vol Aérien. Aerodonétique. Par F. W. LANCHESTER. Traduit de l'Anglais sur le deuxième edition par Le Commandant C. BENOIT. Paris : Gauthier-Villars et Cie. [Price 14 francs.]

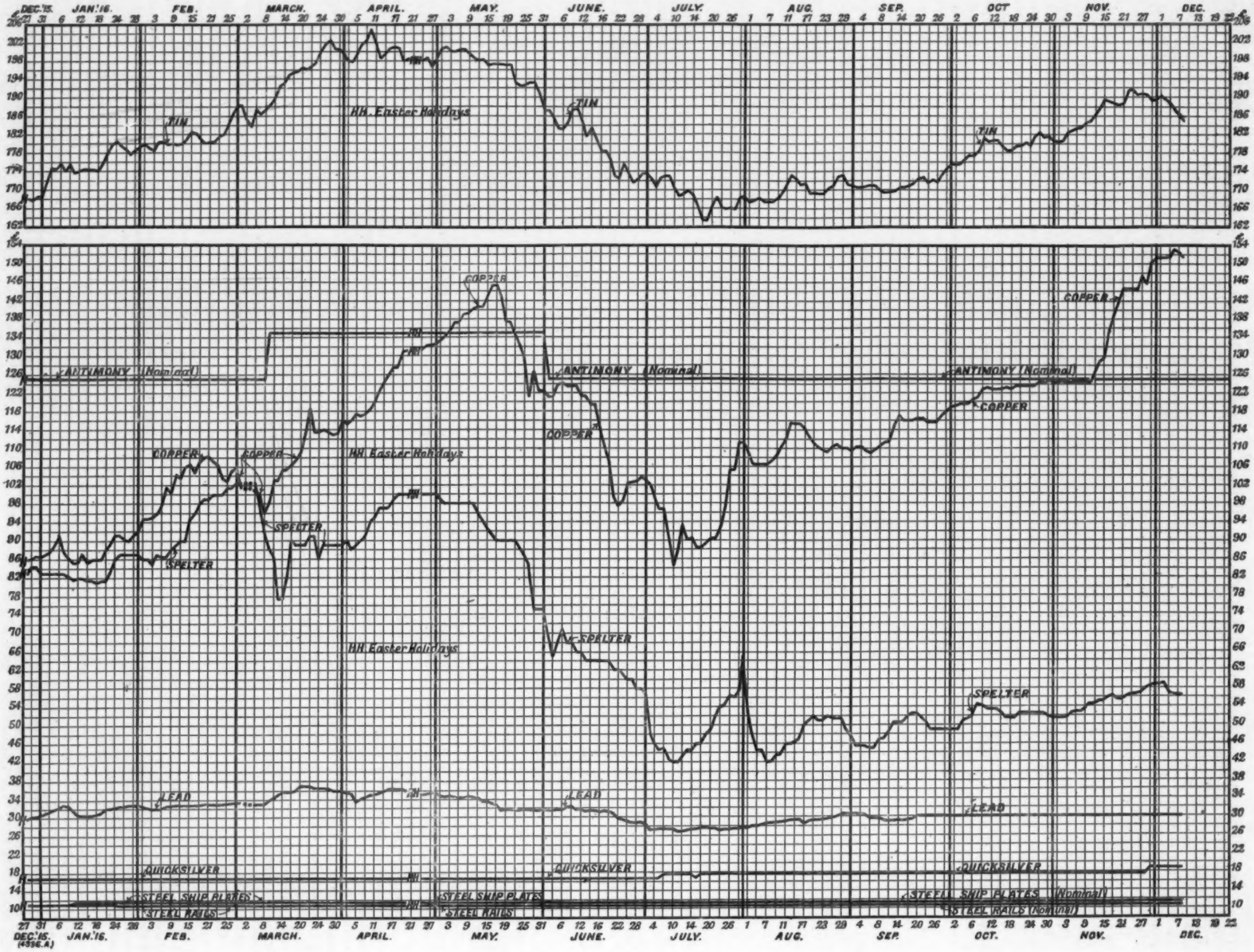
David Gill : Man and Astronomer. Memories of Sir David Gill, K.G.B., H.M. Astronomer (1879–1907) *at the Cape of Good Hope.* Collected and arranged by GEORGE FORBES, F.R.S. London : John Murray. [Price 12*s.* net.]

United States Geological Survey. Professional Papers. No. 89. *The Fauna of the Chapman Sandstone of Maine, including Descriptions of Some Related Species from the Moose River Sandstone.* By HENRY SHALER WILLIAMS, assisted by CARPEL LEVENTHAL BREGER. No. 98–A. *Evaporation of Brine from Searles Lake, California.* By W. B. HICKS. No. 98–B. *Relation of the Wissahickon Mica Gneiss to the Shenandoah Limestone and Octoraro Schist of the Doe Run and Avondale Region, Chester County, Pennsylvania.* By ELEANORA F. BLISS and ANNA I. JONAS. No. 98–C. *Retreat of Barry Glacier, Port Wells, Prince William Sound, Alaska, between* 1910 *and* 1914. By BERTRAND L. JOHNSON. No. 98–D. *Experiments on the Extraction of Potash from Wyomingite.* By ROGER C. WELLS. No. 98–E. *The Physical Conditions and Age Indicated by the Flora of the Alum Bluff Formation.* By EDWARD WILBER BERRY. No. 98–F. *The Physical Conditions Indicated by the Flora of the Calvert Formation.* By EDWARD WILBER BERRY. No. 98–G. *Revision of the Beckwith and Bear River Formations of South-Eastern Idaho.* By G. R. MANSFIELD and P. V. ROUNDY. No. 98–H. *The Flora of the Foxhills Sandstone.* By F. H. KNOWLTON. Washington : Government Printing Office.

DIESEL ENGINE USERS' ASSOCIATION. — At the December meeting of the Diesel Engine Users' Association, Mr. Geoffrey Porter, A.M.I.C.E., borough electrical engineer to the corporation of Worthing, was re-elected president for a second year. The hon. secretary made a general statement of the position of the association and of the work carried out during the year 1916. The total membership was 79, being an increase of 31 Diesel engine users during the year. The total horse-power represented by the association had doubled during the year, being now 46,108 brake horse-power, as against 23,984 brake horse-power at the end of the previous year. The committee had put forward a suggestion that a class of "subscribers" be admitted. A considerable amount of attention had been given during the year to the subject of the use of tar oils as fuel in Diesel engines. In view of the high price of imported fuel oil, and of possible shortage in the future consequent on the conditions brought about by the war, much stress had been laid on the importance of encouraging in every possible way the use of a home product as fuel. As a result several members of the association have already commenced to use tar oils in their Diesel engines, either with a pilot ignition apparatus fitted to the engine or without, and a considerable amount of useful experience has been obtained in the use of this class of fuel. Further trials were still being made with various methods of using tar oil. In reply to inquiries we may state that information and particulars concerning the association can be obtained from the hon. secretary, Mr. Percy Still, 19, Cadogan-gardens, London, S.W.

DIAGRAMS SHOWING FLUCTUATIONS IN THE PRICES OF METALS FROM CHRISTMAS, 1915, TO CHRISTMAS, 1916.

Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.



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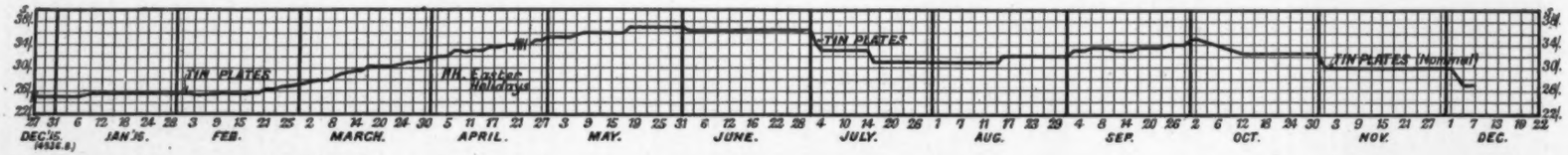
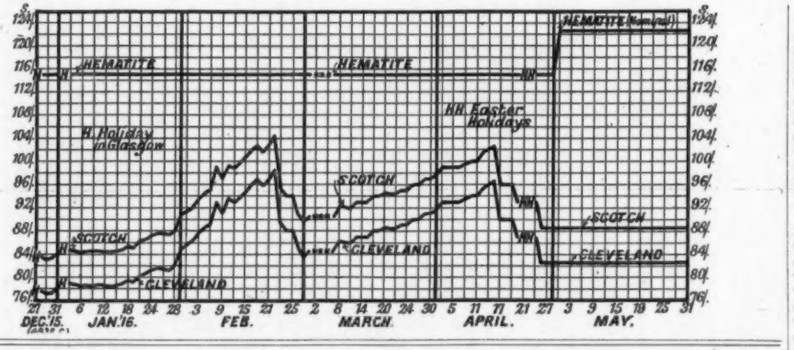




NOTE.—In the diagrams above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for "fine foreign" and "standard" metal respectively. The prices shown for antimony and lead are for English metal in both cases, whilst those for spelter are for American metal. The prices are per ton, but in the case of quicksilver, however, the price is per bottle, the contents of which weigh about 80 lb.; the price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents two market-days, and the horizontal lines represent 2*l.* each, except in the case of the diagram relating to tin-plates, where they represent 2*s.* each. On July 7 the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig was fixed at 6*l.* 2*s.* 6d., Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6d. per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6d. per ton. These quotations are still in force. (For official regulations see page 45 *ante*.)

THE PHYSICAL SOCIETY OF LONDON.

AT the meeting of the Physical Society of London, held on Friday, November 24, 1916, at the Imperial College of Science, Professor C. V. Boys, F.R.S., president, in the chair, a paper "*On the Measurement of the Thomson Effect in Wires*" was read by Mr. H. R. Nettleton. The paper describes how absolute measurements of the Thomson effect may be made in wires. The theory is fully worked out and the sources of error likely to arise —especially owing to the smallness of the area of cross-section—are considered. The method is sensitive, consistent, and very rapid; its ultimate object is to determine the Thomson effect at different temperatures in a number of metals, both rare and base, at the same time, and with the same specimens, finding their thermo-electric powers. The preliminary experiments of this paper, testing the method, are with constantan wires of different lengths, with manganin, and with German silver.

Discussion.—Mr. F. E. Smith suggested that the method might have been modified by having two exactly similar systems arranged in opposite arms of a Wheatstone bridge, so that the current passed from hot to cold in one wire and from cold to hot in the other. Any change in the relative temperatures of the two wires on reversing the current would be indicated by the bridge being thrown out of balance. This seemed preferable to measuring the temperature of a wire by the resistance of another wire wound round it.

Mr. D. Owen thought the method was very satisfactory. Had the author thought of using electrical heating for the hot end in order to get smaller temperature gradients, in view of the high sensibility of the arrangement? He thought the figures of Oosterhuis stood in need of verification. If the author could adapt his method to deal with crystals, such as were employed in wireless detectors, the results would be of very great interest.

Dr. R. S. Willows said that it was difficult to see from the equations which Mr. Nettleton had put down on the board whence the energy was derived in cases such as those mentioned in the paper which Mr. Darling was about to read. In some of these cases dE/dT and d^2E/dT^2 were both zero. It would be useful if the method could be rendered applicable to substances with large temperature coefficients.

Professor W. Eccles said he had hoped that the author would have explained just what the important points of the method were in a less abstract manner—with the aid, say, of diagrams of the temperature conditions along the wire before and after the current reversal.

The author, in a written reply, thanked Mr. F. E. Smith for his suggestion, which, however, as regards sensibility, would depend on the value of the temperature coefficient of resistance, and might carry with it additional complications such as those which enter into King's experiments. In reply to Mr. Owen, the use of electrical heaters would simplify temperature coefficient work enormously, but unfortunately there are mechanical difficulties arising out of the facts that the solder fixing the wire must be applied from behind, and that, in order that the resistance of the wire may be measured as a low resistance *in situ*, the copper must be narrowed down, leaving a very small bearing surface at N.

The author still hoped that he might be able to overcome these difficulties, while ensuring at the same time that the difference of temperature U, measured by the thermocouple, was substantially that between the extremities of the wire. He agreed with Mr. Owen that the results of Oosterhuis should be confirmed, as well as those of Aalderink, in view of the extraordinary conclusions to which they lead; at the same time, he had a very high opinion of the methods adopted at Groningue, and his own results on mercury some time ago were not very different from those of Schoute. In reply to Professor Eccles, the author had himself felt the difficulty of explaining the essence of the method simply and satisfactorily. Graphs of the distribution of temperature afforded little help. What was actually done was explained in a few words in section 2 of the paper, though no simple proof of the formula was given. A "proof" of the formula $\sigma = R(C_2 - C_1)/SU$ was obtained very simply by equating the electrical heat produced per second per centimetre—viz., $C_2{}^2R/SL + C_1\sigma U/L$, when C_1 was passing from hot to cold, to that produced when C_2 was passing in the opposite direction—viz., $C_2{}^2R/SL - C_2\sigma . U/L$. This proof was omitted not so much because it assumed that σ, R and the temperature gradient were constant everywhere, and ignored emissivity, as because it neglected thermal conductivity, or assumed that Joulean and Thomson heat were propagated similarly. In reply to Dr. Willows, the method was equally applicable to wires of large temperature coefficient. Equation (2b) might then be applied, or equation (2c) if the resistance of the wire were measured directly while under temperature gradient, as suggested in section 4D. The author had no satisfactory explanation of the energy problems arising out of the researches in Holland, or those arising from Mr. Darling's experiments: in the absence of measurements of σ and π there were few data to go upon. In the case of Mr. Darling's experiments it must be remembered that though with, say, the bismuth silver couple over the range 300 deg. C. to 500 deg. C., both dE/dt and d^2E/dT^2 were zero, no additional energy or thermo-electric force was manifest. If the law of successive temperatures was true with Mr. Darling's materials, a thermocouple composed of molten bismuth and silver with one junction at 300 deg. C. and the other at 400 deg. C. or 500 deg. C., should show no E.M.F., corresponding to zero Peltier effects and equality of Thomson coefficients.

A paper "*On the Thermo-electric Properties of Fused Metals*," by C. R. Darling, A.R.C.S., F.I.C., and A. W. Grace, was read by the former. One of the authors has for some time been investigating the possibility of using base metal thermocouples at temperatures above the melting-point of one of the constituents. For this purpose it was necessary to determine whether any peculiarities in the thermo-electric behaviour of metals occur at fusion. In the case of lead, tin, zinc and cadmium there is no perceptible break in the continuity of the curves obtained. In couples containing bismuth, however, several cases were noted in which the E.M.F. remained constant for a wide range of temperature after the fusion of the bismuth. This occurs with silver, aluminium, iron or nichrom as the other element. Useful applications of this property are discussed. No attempt was made to construct a thermo-electric diagram from the results, as it would be impossible to obtain correct values of dE/dt at all parts of the curves, many of which show small flexures, without making more accurate measurements in the region of such flexures than was practicable.

Discussion.—Mr. A. Campbell, in a communication which was read by the secretary, remarked that he had made similar experiments (Proc. Roy. Soc., Edin., 1888) on Wood's metal, an alloy of bismuth melting at 73 deg. C. The results of measurements against iron from 8 deg. C. to 150 deg. C., when reduced to a thermo-electric diagram, gave one straight line up to the melting-point, and another straight line, of a different slope, above the melting-point. He disagreed entirely with the authors' remarks on the usual thermo-electric diagram. A diagram of the thermo-electric powers was most valuable, even though the lines might not be straight at the extreme temperatures. If anything was to be deduced from observed results, the first step was to plot the thermo-electric powers against temperature. Why the authors gave results of tests against a whole series of metals was not clear. A set of tests against one metal would have been sufficient to fix the bismuth curve on the thermo-electric diagram, and all the other results could then have been deduced from the curves of the other metals already determined by more exact methods.

The president expressed himself puzzled by the results shown in one of the figures. Up to the melting-point of bismuth the different metals gave with it increasing E.M.Fs. At the melting-point, however, discontinuities occurred, and it appeared that if one eliminated bismuth by subtracting the ordinates of one curve from another, discontinuities would also occur, at the melting-point of bismuth, in the properties of the couples obtained by combining the other metals *inter alia*. This, of course, was not true.

Professor Howe pointed out that there was not a marked discontinuity in the difference of the nickel and copper curves when this was plotted. The president's remarks held, however, in the case of silver with either of the others.

Mr. S. W. Smith pointed out that bismuth was abnormal, in that it contracted on melting.

Dr. R. S. Willows mentioned that the metals lead, tin, zinc and cadmium, which had been shown to have no thermo-electric discontinuities at their melting-points, happened to be those which, as Mathiessen had found, formed alloys with one another of which the specific resistance could be deduced from the percentage composition. He suggested that the discrepancy mentioned in the case of iron might possibly be due to the occurrence of some allotropic modification, in which case there was really a change in the substance, and it was unfair to extrapolate the thermo-electric diagram beyond the change-point.

Mr. Darling, in reply, said he had no doubt that Mr. Campbell's remarks would hold if one could get out the proper thermo-electric diagram. Owing to the numerous little kinks which occurred, very sensitive temperature measurements were required. If really accurate diagrams could be obtained it might then be possible to deduce the properties of any bismuth couple from those of one, as Mr. Campbell suggested. They had tried this in a few cases, however, but did not get good agreement. He did not know whether the peculiarity of bismuth which had been mentioned was related to the phenomena which they had described. Bismuth was a freak metal in many respects. He was unable at the moment to solve the difficulty raised by the president. Their aim had been, primarily, a practical one, and they had not gone as fully into points of that nature as might have been desired.

INDUSTRIAL NOTES.

The Minister of Munitions, in the exercise of his powers under Section 6 of the Munitions of War (Amendment) Act, has made and is issuing a new Order regulating the employment and remuneration of women employed on munitions work customarily done by men. This Order amends and re-enacts the Order commonly known as Circular L. 2. The effect of the amendments is to guarantee to women employed on the work of men other than skilled men 1*l.* for a week of 48 hours, with an additional 6*d.* for every hour of which the normal working week exceeds 48 hours, and to permit of advances beyond these rates in the case of women employed on semi-skilled, specially responsible or specially laborious work. No alteration has been made in the provisions of the original Circular regarding women who replace fully skilled men; but a fresh Order on this subject will be made shortly.

The Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm (Consolidation) Act, 1914, the Defence of the Realm (Amendment) No. 2 Act, 1915, the Defence of the Realm (Consolidation) Regulations, 1914, the Munitions of War Acts, 1915 and 1916, and all other powers thereunto enabling him hereby Orders as follows:—

No person shall, until further notice, sell or supply any crane, whether steam, electric, hydraulic or hand-driven, except under and in accordance with the terms of a permit issued under the authority of the Minister of Munitions.

The monthly report for December issued by the United Society of Boiler Makers and Iron and Steel Shipbuilders states that the balance at September 30 was, in round figures, 452,560*l.*; that at June 30 was 431,960*l.*, showing a net increase for the quarter of 20,600*l.* The total membership was over 75,000.

The monthly report, dated December 8, of the Steam Engine Makers' Society shows the membership to be 21,000 and the capital 190,000*l.* Only two members were unemployed.

The Ministry of Munitions are advised that apprehension exists amongst employers as to the effect of the instruction of December 18 upon the output of essential munitions of war, and that the semi-skilled and unskilled men who alone are affected by this direction are in some doubt as to their duty in the circumstances thereby created.

The Ministry therefore desire to emphasise the general consideration which governed the issue of this instruction—the supply to the army of men fit for general service and under the age of 31 years. Under the procedure arranged, no man debadged and decertificated by the general instruction will be called to the colours except after consultation and by agreement with responsible officers of the Government Departments concerned. These officers will decide where substitutes are necessary, and the substitutes will be offered to employers so as to secure the least possible disturbance in the output of munitions.

Apprentices of military age who comply with the provisions of the trade card scheme, and who are classed on the register of their employers as semi-skilled, should be specially indicated on all returns made by employers.

The Ministry of Munitions desire to urge upon all men affected by the general instruction of December 18 that it is their imperative duty to remain at their present posts in munition works, and to continue to exert every possible effort to maintain and increase the output of munitions, unless and until they are called upon for any other form of national service.

The editor of *La Métallurgie*, Paris, states that he has visited a large French works which has made the manufacture of forgings one of its specialities. In this works all the steam and compressed-air hammers are now operated by women. The foreman, on being questioned by him with reference to the results obtained by female labour in the forging shop, expressed his complete satisfaction with the "female hammermen." They have a surer eye and are much more dexterous than the labourers who formerly did the same work. There have been fewer accidents through lack of skill and particularly fewer false strokes.

According to the Board of Trade returns for November, a great deal of overtime has been worked in all industries in order to make up for the shortage of labour. In the pig and iron industry employment continued good, and was better than a year ago. Detailed returns showed that 289 furnaces were in blast at the end of November, compared with 287 a month ago, and with 265 for the corresponding month in 1915. Employment at iron and steel works continued to be very good. The returns showed that 111,932 workpeople were employed. The aggregate number of shifts worked during the week ended November 25, 1916, was 642,705, showing an increase of 9,365 (or 1.5 per cent.) over October, and of 34,710 (or 5.7 per cent.) over a year ago. In the South Wales and Monmouthshire district the increase in the number of people employed was 0.4 per cent. over that of October, and 8.1 per cent. over that of November, 1915. The engineering trades continued to be extremely busy; there being a scarcity of labour, a large amount of overtime was worked. Shipbuilding activity was maintained at a high pressure. In the tinplate trade the number of works open at the end of November was 83, or two more than a month ago. but five less than in November, 1915, and the number of mills in operation was 347, or 145 less than a year ago, of which 121 represented tinplate mills. Although the number of works in operation showed an increase, the output of tinplates was less owing to short time being worked at many mills.

The following figures illustrate the growth in the production of ammunition and guns in England since the war begun, taking 1 per week at the end of June, 1915, as the unit for comparison:—

Ammunition.	Average Weekly Production at the end of June, 1915.	Average Weekly Production from July 1, 1915, to June 30, 1916.	Week Ended July 1, 1916.	Week Ended Nov. 25, 1916.
18-pdr.	1	6½	17½	43
Field Howitzers (4.5 in.)	1	8	27	46
Medium Guns and Howitzers ..	1	7½	34½	66
Heavy Howitzers (above 6-in.) ..	1	22	94	323

With regard to guns, taking 100 as a basis for the number of guns manufactured during the first year of the war, the following table is obtained:—

Guns.	First Year.	Second Year.	July 31, to November 29, 1916 (four months).
18-pdr.	100	240	45
4.5-in.	100	654	104
Medium (60-pdr. and 6-in.)	100	1,848	1,200
Heavy (over 6-in.) ..	100	623	363

The manufacture of 18-pdr. guns has had to be slackened during the last period, the equipment of the British army in light field pieces being approximately complete. If the average monthly production of guns of all calibres be considered, a considerable development can be observed on comparing the results of the first year with those of the second period of 1916:—

	Monthly Average for the First Year.	Production during the Five Weeks ended December 2, 1916.
18-pdr. ...	100	138
Medium ...	100	4,100
Heavy ...	100	1,250

The figures for the manufacture of the 4.5-in. gun are not included in this table, the reserve of pieces of this calibre being complete.

The manufacture of machine guns, rifles, grenades, explosives, &c., has also increased rapidly in very great proportions.

Materials and Economy Committee.—The Minister of Munitions announces that the Metals and Materials Economy Committee recently appointed under the chairmanship of Mr. C. W. Fielding will "consider and suggest the action necessary to secure economies in metals and materials as regards their use in munitions of war, taking into consideration matters affecting design, methods of purchase, stocks, import, distribution and control, with powers to take such evidence as may be necessary both from the Departments of the Ministry and from manufacturers."

Society of Glass Technology.—The second meeting of the above society was held on Thursday, December 14, at 6 p.m. in the University of Sheffield, the president (Mr. W. F. J. Wood, B.Sc.) taking the chair. Dr. H. Frank Heath, C.B., of the Advisory Committee of the Privy Council, addressed the meeting, pointing out the good services the society could render to the nation, and assuring it of the Government's interest and support. The remarkable developments that have taken place in the glass industry during the last two years were emphasised by an exhibition of various types of glass, including (*a*) scientific ware, (*b*) optical glass, (*c*) artistic glass, (*d*) miscellaneous exhibits. Many firms and private individuals sent collections for exhibition, and it was apparent that in chemical ware and other scientific glass there was no necessity to depend on German production in the future. Beautiful specimens of artistic glass, both ancient and modern, were shown, whilst there were several interesting and instructive exhibits of glasses illustrating various phenomena met with in glass production.

RELATIVISTS.

To the Editor of Engineering.

Sir,—Now that Mr. Edwards knows that I am serious will he kindly try to be serious too?

The query "propounded" by me was based on his statement in Engineering of November 24, page 515, column 2, lines 8 to 10:—"Let the line Oy represent the amount of energy or momentum E entering at W in the direction of WD"; and, by way of explanation, we are now offered a quotation, with which Mr. Edwards does not agree, from our greatest authority on communications with the dead! But this is not a proper reply to my question; so let me ask more plainly, does Mr. Edwards look upon energy as a separate entity that can enter at W or anywhere else?

Heat is a mode of motion and, therefore, a form of energy; but the temperature of any substance is not raised by heat entering into it. Motion is, as I pointed out in my first letter (August 25), merely the condition of a body whose position is changing relatively to other bodies; and we cannot put motion into a body, though we may set it in motion. While in motion a body has energy, that is, *capacity for performing work*, as Rankine taught more than sixty years ago. Such energy cannot be transferred, though it may be exerted in doing work, say, in setting other bodies in motion by which they acquire energy—not the energy of the body by which the work was performed, and so on *ad infinitum*.

My object is not to quibble or to pose as a purist, but, to show that, by careless use of expressions, we may easily get into the way of mistaking words for things; and I thank you, Sir, for assisting in my endeavour to make people more precise in their statements and clearer in their thinking. There is still far too much Relativity-Fog about; and Mr. Edwards might help us, if only he would, to drive it away.

Christmas Day, 1916. Sesamy.

Refractory Materials.—A well-attended meeting of makers and users of firebricks and other refractory materials was held in the chemistry theatre of the University of Manchester, on Wednesday, December 13. Mr. A. Cliff, of Stamford, presided, and representatives from practically all the important manufacturing centres were present. The general opinion was that a technical society of some kind ought to be formed, which should emphasise the manufacturers' side and develop close relations with the users in the various industries, so that all may work together in harmony for the common good. After some discussion it was arranged to form a special section of the Ceramic Society, which is largely concerned with refractory materials, and has long been established, with headquarters at Stoke-on-Trent. This new section is to work independently of the parent association, in regard to electing its own officers and managing its own meetings in the different centres. A provisional committee was appointed to meet at Newcastle-on-Tyne on Wednesday, December 20, in order to formulate a scheme for the election of officers, to consider what modifications of the rules of the Ceramic Society are necessary to meet the requirements of the special refractory section, and to appoint a place for the next general meeting of the section. At the Newcastle meeting it was arranged to hold the next general meeting of the section early in the coming year at Leeds, when Dr. J. W. Mellor, of Stoke-on-Trent, is to read a paper on "The Spalling of Magnesite Bricks."

Carbon Tetrachloride instead of Oil for Electric Switches.—To replace the oil in electric switches by carbon tetrachloride was proposed by E. Peyrusson, of Paris, in 1908. But he did not do much more than patent the suggestion. Dr. Vogelsang, of the firm of Voight and Haeffner, we see, from the *Electrotechnische Zeitschrift* of March 23, 1916, took up the problem of the technical suitability and utilisation of this compound in 1911, and resumed his investigation in 1914 when oil became scarce. Carbon tetrachloride, it appears, has some undesirable properties. It is heavy, having a specific gravity of 1.63, and is volatile, the boiling-point being 76.5 deg. C.; vessels charged with the chloride are heavy, therefore, and lose 1 mm. of liquid per day if not covered. Aluminum, silver and lead are hardly attacked by the compound; copper keeps fairly well in it, as long as the temperature remains below 45 deg. C. At higher temperatures copper is badly corroded. Tin and tinned metals are not corroded. Rubber, vulcanite and micanite are destroyed; mica and fibre are not attacked. As regards dielectric strength carbon tetrachloride is at least equal, if not superior, to oil, provided that high tension be not applied for intervals of more than a few seconds. When high tensions are maintained for minutes, eddies are set up in the liquid, and the insulation may fail. To avoid evaporation of the tetrachloride, a layer of glycerin may be poured on the surface; the glycerin is a fairly good conductor, however, and as it adheres to the metal, when once in contact with it, short circuits, giving rise to heating and emission of smoke from the decomposed glycerin, may arise. The volatility of the tetrachloride is a drawback also for another reason. When a leak occurs in an oil switch, the escape of oil betrays itself; one tetrachloride box had run dry without anybody suspecting it. When sparks pass under the tetrachloride, the metals are corroded. Vogelsang, hence, would not recommend the use of carbon tetrachloride alone; mixed with oil, *e.g.*, 1 part of tetrachloride and 3 parts of oil, it will answer. Yet he would prefer some other substitute for oil.

THE PYRENE FIRE EXTINGUISHER.

CONSTRUCTED BY THE PYRENE COMPANY, LIMITED, LONDON.

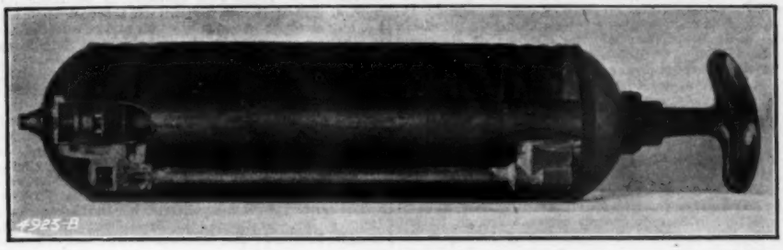
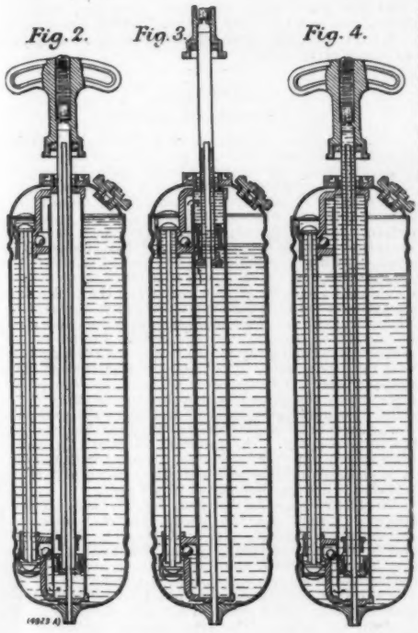


FIG. 1.



THE Pyrene fire extinguisher is a pump and a reservoir combined. The problem which faced the designer was so to construct it that it might be used by one person in all positions. If it had been intended for dealing with fires on the ground only the matter would have been simple enough, but a domestic and commercial fire-extinguishing appliance has often to be directed upwards to spurt its liquid on to blazing curtains and the like. At other times it needs to be held horizontally, and in every case the liquid runs to the lowest part of the reservoir, from which it must be drawn into the pump barrel. Clearly the suction valve must always be below the liquid, and as the reservoir is cylindrical and can be grasped at any part it needed very considerable inventive skill to meet the conditions without imposing any restrictions on the use of the extinguisher.

A glance at our illustrations will reveal the method adopted. It will be seen that the nozzle is at the end of a tube or hollow rod, which acts as a stationary plunger, and is fixed at the end of the appliance remote from the handle; the bottom end of the pump barrel can rotate around the rod at this end. At the other end a cap on the pump barrel can rotate around the hollow piston rod. At each end of the pump barrel there is a valve-box containing a clack valve and a ball valve, the two valve-boxes being connected by a tube in which is a rod coupling the two clack valves together. These valves and valve-boxes, being on one side of the pump barrel, which is free to rotate, always tend to fall into the lowest position possible to them, as shown in Fig. 1. If the extinguisher be nearly vertical, as in Figs. 2 to 4, gravity has no effect on the valve-boxes, but at any moderate inclination from the vertical, as well as in the horizontal position, the pump barrel rotates until one or both of the valve-boxes are drowned.

Of course, only the suction which is under the liquid must be in use at a time, and for this reason the two clack valves are connected by a rod which slides endways when vertical or inclined, closing one of the clack valves and keeping it shut. The other remains permanently open while the reservoir is maintained in the same position, the lower ball acting as the suction valve. The piston or bucket of the pump is not fixed to the piston rod, but is free to slide a short distance endways along a sleeve fixed to the rod. In this sleeve there are two ports at opposite sides, and these ports afford communication from the pump barrel to the interior of this hollow piston rod. The travel of the piston on the sleeve is about three times the length of the ports, so that the ports are always open, except at the moment when the piston is travelling over the sleeve at the commencement of the stroke of the piston rod.

Fig. 2 shows the extinguisher in a vertical position and the pump barrel empty. If the piston rod be now drawn up by the handle, liquid will flow from the reservoir past the lower ball valve into the pump barrel for the entire length of the stroke. When the stroke is reversed the rod and sleeve will move first, opening the ports below the piston and affording communication between the full pump barrel and the inside of the hollow piston rod. The piston will then descend, forcing the liquid first into the hollow piston rod, and then through the hollow fixed plunger, which has a nozzle opening in the centre of the hemispherical end of the extinguisher. At the same time liquid will be drawn past the lower clack valve, which is open, up the valve tube and past the upper ball valve, into the upper part of the pump barrel (Fig. 3).

At the next up-stroke of the piston the liquid in the upper part of the barrel goes through the sleeve, the hollow piston rod and the hollow plunger to the nozzle, and thus there is a delivery both on the in and out strokes.

The circle of operations just described is for the extinguisher in a vertical position, as shown in Figs. 2 to 4. If it were horizontal, as in Fig. 1, both clack valves would be under the liquid and might possibly be open, and then each side of the piston would draw through the corresponding clack valve. If the pump were inverted to deliver towards the ceiling, then the upper clack valve would be closed, and the suction at the nozzle end would draw through the valve tube. The extinguisher is filled through the cap at the upper end, and in this cap there is a valve such as is used on bicycle tyres to allow air to enter as the liquid is ejected. This liquid, of which there is one quart, is stated to be neither acid nor alkaline, so that it will not attack either the apparatus itself or any object on to which it may be thrown. It does not contain water, and is a non-conductor of electricity, so that it can be directed on to a "short," a very valuable feature in electric supply works. Further, it will not freeze.

As the nature of the liquid is kept secret we can only reproduce the information given us by the makers, but very numerous public tests which have been made seem to afford ample confirmation of their claims. As to the mechanism, our readers will be able to see for themselves with what ingenuity each point has been thought out, and how extremely handy is the appliance. Of course, handiness and capacity are somewhat antagonistic and cannot be combined to any great extent. The makers have considered that as every fire is very small at the beginning it is of far more importance that an extinguisher should be easy to operate and that its jet should be under complete control, than that it should contain a great quantity and weight of chemical. Capacity can be attained by providing a number of extinguishers. Large orders have been received from the Admiralty and other Government departments by the makers, the Pyrene Company, Limited, 19, Great Queen-street, London.

VARIABLE-SPEED GEARS FOR MOTOR ROAD VEHICLES.*

By ROBERT E. PHILLIPS, Member, of London.

(*Concluded from page* 627.)

Epicyclic Gear.—After the sliding type of shaft-to-shaft gear, the epicyclic gear has found most favour, and while this type of change-speed gearing has been successfully employed in some motor road vehicles for many years, its application can only be considered as limited when compared with the sliding type of gear. While popular prejudice, which is always in favour of the thing which is known and understood, may account for its lack of adoption, it cannot be overlooked that as compared with the sliding type of gear its cost of manufacture, by reason of the necessity for a high standard of workmanship, is high, the number of its parts is comparatively large, it is difficult to obtain a useful ratio of speed-when three forward speeds are required without complication, and it calls for adjustment at intervals. Against these drawbacks it has several advantages over the sliding type of gear. For instance, it is practically silent on all speeds, it is less liable to break down or to be damaged through careless handling, and it is not subject to as much wear and tear. It will be seen, therefore, that while the disadvantages are nearly all matters for the manufacturer, the advantages are all on the side of the user. The best known gear of this type, giving three forward speeds and a reverse, is the Lanchester, Fig. 12 (Appendix, page 653), which has been used continuously and to the exclusion of all other types of gear in the Lanchester cars since 1900.

The Ford car may also be cited as an automobile in which the epicyclic type of change-speed gear is exclusively used, and in this case the increased cost of production of this type of gear certainly has not been a bar to its use, as the total cost of production of this car is known to be well below that of any other car of similar power and capacity, while its selling price has become a byword. It must, however, be borne in mind that the gear fitted to the Ford car only provides two forward speeds.

Nothing is more fascinating than the possibility of effecting a smooth and gradual change of speed over the whole desired range, whereby the prime mover can always be kept running at its most effective speed. The exceedingly flexible petrol internal combustion engine of to-day has eliminated much of the need that once existed for a gradual and infinitely variable change-speed gear, but the advantages of such a mechanism seem so apparent that much ingenuity has been exercised in the attainment of it.

Variable-speed Mechanisms.—The various mechanisms for obtaining a gradual and infinitely variable speed may be classified as follows:—

1. A mechanical system in which expanding pulleys and belts are used,
2. A mechanical system in which the drive is by fractional contact,
3. A mechanical system in which the drive is on the feed-gear principle,
4. An hydraulic system, and
5. An electric system in which current generated by a dynamo driven by an engine is employed, either wholly or partially, as the transmitting medium between the engine and the road wheels.

Belt Gearing.—Belt gearing is now only used on light cars of the so-called cycle type, and expanding pulleys are successfully employed to vary the speed ratio. These are almost invariably of the double-cone type, so that the belt used with them has the shape of an inverted truncated cone, which gives the belt a better grip on the pulleys. In some cases two such pulleys are employed, so coupled together that as one is expanded the other is contracted, while in other cases one expanding pulley is employed, the slack being taken by a spring-controlled jockey pulley. In all these systems belts are employed, as an expanding pulley capable of running with a chain is not yet a commercial proposition.

Friction Gearing.—A common form of frictional drive mechanism (Fig. 17, Appendix, page 653) consists of two friction discs arranged at right angles to one another, so that the periphery of one engages the face of the other, the relative positions of the axis of one and the path of rotation of the other being capable of being varied. An interesting modification of this type of gearing is the Cowey (Figs. 18 and 19, Appendix, page 653) in which the driving and driven discs engage one another face to face.

Feed-Motion Gearing.—The most common form of variable-speed gear working on the feed-gear principle is one in which reciprocating pawls operate ratchet wheels, provision being made whereby the angle through which the pawls travel can be varied. This type of gear has not obtained any hold in automobile construction, due probably to the large number of working parts and the high speed at which the reciprocating parts must work if the size of the gear is to be kept within reasonable limits. The great defect, however, of this type of gear is that when the engine speed is slow, and especially when the torque is heavy, the driving motion is apt to become jerky. Several gears—for instance, the Newman and the Barber—have passed through the experimental stage with apparent success, but the fact remains that they have not been successfully used commercially.

Hydraulic Transmission.—In hydraulic transmission there are two essential elements, a pump (driven by the prime mover) by which the working fluid is put and transmitted under pressure, and an hydraulic motor (by which motion is transmitted to the road wheels of the vehicle)

* Paper read before the Institution of Mechanical Engineers on Friday, December 15, 1916.

driven by the pump. These two elements are suitably connected, so that by varying the output of the pump per revolution the power imparted to the road wheels can be varied as desired, as if the speed of the engine is kept constant the effect of lowering the volume of liquid pumped is to increase its pressure in the same ratio.

The advantages claimed for hydraulic transmission are: (1) That as all the mechanism is enclosed, and works in oil under pressure, friction is reduced to a minimum, and damage is practically impossible; (2) that a change of speed can be effected without any jar or strain on the prime mover; (3) that it is extremely smooth and comparatively quiet in running; (4) that in changing gear there is no necessity to disconnect the prime mover; (5) that the gear can be adjusted to the constantly varying requirements of the prime mover without checking the momentum of the vehicle, and, finally, that it is simple in action, durable, and economical in working.

The various types of hydraulic transmissions that have been introduced only differ from one another in the type of pump and motor employed and in various details of construction and control, and two of them are described in the Appendix, namely the earliest (the Hall, Fig. 20, page 654), and the latest (the Compayne, Figs. 21 to 27, page 654), which is associated with the name of Dr. Hele-Shaw. The practical advantages of the Hele-Shaw system are that the pump has a uniform and steady discharge under all pressures; that sliding friction is reduced to a minimum, whereby the total efficiency of the pump is materially increased; that the rotating parts of both pump and motor are perfectly balanced; that there is no end-thrust in either the pump or the motor, owing to all the forces being in the plane of rotation; that all the parts are simple, and those that require any great degree of accuracy are cylindrical; that there is a minimum of wear on any of the parts; that although high pressures are employed no packing glands are required; that owing to the rotary form of the valve the slip of oil past the valves is reduced to a minimum because the oil pressure does not tend to open the valve, and that the inertia forces in both pump and motor are perfectly balanced. It is claimed that a long series of tests of a pump running at 1,000 r.p.m. show an efficiency of 73 per cent. at quarter stroke, of 80 per cent. at half stroke, and an overall efficiency of 90 per cent. at full stroke. The mechanical efficiency of the motor is put at 95 per cent., and this efficiency is stated to be largely due to the fact that the motor works at a considerably slower speed than the pump. The combined efficiency of the whole system from engine to road wheels, including the loss in the conducting pipes due to the viscosity of the oil, as shown by trials, averages over 70 per cent. at all speeds between 5 and 15 miles per hour. The efficiency at 8 miles per hour being 76 per cent. and at 12 miles an hour 72 per cent.

Electric Transmission.—Electric systems, or, as they are more properly designated, petrol-electric systems, owing to the prime movers employed being of the internal combustion type, may be conveniently divided into four groups:—

1. In which the surplus power of the engine is stored in the form of electric energy in a battery of accumulators and is given out when required to augment the power of the engine, of which the Pieper or Auto-Mixte may be taken as an example.

2. In which the entire power of the engine is converted into electrical energy, which is absorbed continuously by an electric motor driving the road wheels of the vehicle, of which the Stevens may be taken as an example.

3. In which electric energy is employed to start and accelerate the vehicle, after which the drive from the engine to the road wheels is transmitted through a magnetic clutch, of which the Germain may be taken as an example.

4. In which the electric energy is wholly or partially employed to start and accelerate the vehicle, after which the electric drive is cut out and the power is transmitted from the road wheels mechanically, of which the Thomas may be taken as an example.

Details of these four examples are given in the Appendix. Many more or less divergent forms and combinations of these systems have been adopted by various investigators, but they only differ in details of construction and arrangement.

Considerable divergence of opinion exists as to which of these petrol-electric systems is the best, and although it may well be argued that each is best adapted for a particular class of work, there is no gainsaying the fact that the second system is the only one which has been used on a commercial scale for any considerable length of time. Dealing, however, with these systems in their numerical order, the points in favour of the first system are that the surplus power of the engine is being continuously stored in the form of electric energy which is available for use when the power of the engine requires to be augmented, and that the engine and dynamo run at a constant speed, which enables the former to be run to the best advantage and enables the latter to produce a current of suitable voltage to charge the accumulators at the proper rate.

The points in favour of the second system are, first, its simplicity, as the whole of the power of the engine is converted into electrical energy, which is transmitted direct to the motor driving the road wheels; secondly, the small number of its parts; and thirdly, as the speed of the engine is independent of that of the vehicle it can be run at the speed at which it gives its maximum power and efficiency. It is claimed for the Stevens transmission that the overall commercial efficiency running in normal omnibus service is 79 per cent., and that this efficiency arises chiefly from the great economy both in petrol consumption and in general upkeep. The factors which make for economy in petrol consumption are the slow speed of the engine as compared with the speed of the transmission shaft, and the ability of the vehicle to free-wheel, *i.e.*, run without propulsion, for a considerable part of its running time; while the factors which make for economy in upkeep are: (1) the simplicity of the transmission, in which no gear-wheels, no clutches, and no battery are employed; (2) the absence of transmission stresses due to the elasticity of the electrical drive; (3) the absence of clutching and de-clutching as obtains in mechanical gearing; and (4) the non-breaking of any electrical circuits during driving. This system has been used in the Tilling-Stevens omnibuses and other public service vehicles for several years. In the London service alone these omnibuses have run over 6,000,000 miles at an estimated cost of 7.132*d.* per mile; while in the running of over 3,000,000 miles on solid rubber tyres in the London service of omnibuses an average of 20,148 miles per tyre has been obtained.

The advantages claimed for the third system as compared with the first or second systems are, first, that when the load is within the capability of the engine the drive between the engine and the road wheels is practically, though not absolutely, mechanical, at which time the electrical losses are reduced to a minimum; and, secondly, that the mechanism can be used for braking purposes. Against these, however, is the serious drawback that mechanical means has to be employed for the reverse, in addition to which the double commutator adds to the complication of the control. It is also claimed for this system that as the electrical equipment is used solely, or mainly, for starting and accelerating, the equipment can be made comparatively smaller, lighter and cheaper; but this would seem to be a fallacy, as the output of the electrical equipment cannot be confined to starting and accelerating duties only, for the simple reason that occasions must arise when more power than can be obtained on the direct drive will be called for, thus making it necessary to use the electric transmission. As this is the most severe duty that the electrical equipment can be called upon to perform, it must be of such proportions as will propel the vehicle during the whole working period without over-heating if trouble is to be avoided.

As regards the fourth system, this is considered more economical than a direct electrical transmission, but against this must be set off the complications which arise from the introduction of the planetary gear and the clutches. The Thomas transmission has undergone two trials under the auspices of the Royal Automobile Club. The first trial was a with 36 h.p. Leyland lorry over a distance of 2,008 miles, the running being continuous day and night. The weight of the lorry unladen was 4.502 tons, and the weight of the load, including passengers, 3.181 tons, making a total of 7.683 tons. The running speed was not to exceed 12 miles per hour, and averaged (running time only) 10.47 miles per hour; the fuel consumption worked out at 7.555 miles per gallon, giving 58.046 tons-mile per gallon calculated on the gross weight and 24.030 miles per gallon calculated on the net load. During the trial no work was done upon the transmission with the exception of lubrication, for which 5½ oz. of oil were used, and at the end of the trial the whole of the transmission, with the exception that the teeth of the double helical planetary wheels were somewhat worn, and two brushes, four sparking tips, and one brush contact point were sufficiently burnt to require renewing, was in good condition. The second trial was with a 12–16 h.p. Delahaye car from London to Edinburgh and back, in which test the fuel consumption was approximately 35 miles to the gallon, giving 67.9 ton-miles per gallon. An omnibus fitted with this transmission and running in a regular service in London has given from 10¼–11 miles per gallon of fuel. It would therefore seem that the claim that this system is more economical than the direct electrical system is well founded.

Petrol-electric systems are without doubt handicapped as compared with the sliding type of change-speed gears —at all events for use in pleasure and light commercial vehicles—first, on account of excessive weight, and, secondly, on account of lack of power of rapid acceleration. As regards weight, it does not appear possible to make this compare favourably with the mechanical types of variable gearing without seriously risking its efficiency and even breakdown under severe duty.

With respect to acceleration, it must be borne in mind that sudden acceleration of the engine—which in a purely mechanical transmission is at once transmitted to the road wheels—only results, in a petrol-electric system, in an increased generation of electricity in the dynamo, which is followed later by increased speed of the electric motor as the magnetic flux is built up in the generator, and therefore an appreciable time elapses before the current has had time to make its influence felt at the road wheels. For heavy commercial work neither the increased weight nor the sluggishness in acceleration is a matter of much serious moment, and the latter defect may even be a blessing in disguise, as it affords a means of cushioning any shocks that may be set up in the transmission system by unskilful or careless driving. As petrol-electric systems allow of maximum acceleration without subjecting any part of the vehicle to undue strain, they have, as compared with mechanical gears, the great advantage that they place the most incompetent driver on a par with the most experienced and careful driver using a mechanical gear, and it is questionable whether —at all events for commercial work—the inability to accelerate rapidly is not more than compensated for by the saving in wear and tear arising from absence of shocks and undue strain.

Comparing petrol-electric transmission with hydraulic transmission, there does not seem to be much between them on the score of being noiseless, of not being affected by the distortion of the frame of the vehicle, and of giving a smooth acceleration and retardation. Theoretically, each seems to be an ideal transmission for motor road vehicles, and if this paper serves no other purpose it should at all events produce a discussion amongst the upholders of these two systems as to their relative merits, and it is not difficult to forecast that the upholders of these two systems will not be allowed to have it all their own way by the upholders of the sliding and epicyclic types of wheel gearing.

Neither the total losses on transmission nor the losses through the variable-speed gear alone under road conditions are accurately known, and will not be until some means is devised by which the actual power given out by the engine at any moment under and during running conditions can be accurately ascertained. From hill-climbing trials of cars whose maximum engine power is known the total losses in transmission have been estimated to vary from 20 to 50 per cent.

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APPENDIX.

(*Concluded from page* 629.)

Humphris Gear.—A gear similar to the Sizaire-Naudin is the Humphris gear, which consists of a pinion—having hemispherical teeth—mounted on the end of the propeller shaft which gears with one or other of a series of countersunk holes or hemispherical recesses in the face of a disc mounted on the differential gear-box of the axle to be driven. Each of the concentric rows of holes or recesses represents a different gear ratio, the slowest speed being obtained when the pinion on the propeller shaft is in engagement with the outer row of holes or recesses in the driving disc, and the highest gear when the pinion is in engagement with the innermost row of holes or recesses. The end of the propeller shaft is so mounted that it can be moved transversely within certain limits, for the purpose of bringing the pinion in and out of engagement with the driving disc. To change the gear the end of the propeller shaft is swung over to disengage the pinion, after which the pinion is moved longitudinally on its shaft to bring it into position to engage the particular row of holes or recesses in the driving disc which will give the desired speed. The propeller shaft is then swung back to bring the pinion into engagement with the disc. It is claimed for this gear that there is no side thrust and that it has an efficiency of 85 per cent.

Lanchester Gear.—In this gear, Fig. 12, there are three epicyclic trains, the sun wheel, planet wheels and annulus of which are denoted by A, B and C; D, E and F, and G, H and J respectively, the first train giving the first or lowest speed, the second—in combination with the first—the second speed, and the third the reverse. The third or highest speed is obtained by locking the gears together by the action of a clutch which, as shown, is of the multiplate type. The essential feature of this gear is the compounding of two trains to produce the second or intermediate speed, the interaction being obtained from the driven element. The sun wheels A and G of the first and third trains respectively are fixed on the driving shaft V, which is a continuation of the crankshaft of the engine. The driving shaft also carries the inner or male parts of the friction clutch, the female or outer parts of such clutch being carried by a casing U, which is in permanent couple with the driven shaft W. Coupled with the casing U is a sleeve K, which is loosely mounted on the driving shaft V and carries a carrier L for the planet pinions B of the first train, this carrier, therefore, being in permanent direct couple with the driven shaft. The annulus C of this train is carried by a sleeve N, which is loosely mounted on the sleeve K and carries a brake drum M. The sun wheel D of the second train is fixed on the boss of a disc O, which is loosely mounted on the sleeve N and carries a brake drum P. The planet wheels E of the second train are carried by a carrier Q, which is fixed to the sleeve N, and therefore in permanent direct couple with the annulus C of the first train. The annulus F of the second train is carried by a disc T, which is fixed on the sleeve K, and is therefore in permanent direct couple both with the carrier L of the first train and also with the driven shaft through casing U of the clutch, the couple between the sleeve K and the casing U being by means of a dog-key carried by the boss of the disc T and engaging a recess in the boss of the inner flange of the casing U. The planet wheels H of the third train are carried by a carrier R, which is loosely mounted on the driving shaft V and carries a brake drum S, and the annulus J of this train is mounted on a disc J1, which is fixed to the carrier L of the first train, and is therefore in permanent direct couple with the driven shaft. It will be seen that the sun wheel A, the sun wheel G, and the inner or male part of the clutch are all coupled to the driving shaft, and therefore revolve at the same speed. Also that the outer or female part of the clutch and the sleeve K, and therefore the pinion carrier L, are coupled to the driven shaft.

To obtain the lowest speed, the drum M is held stationary, and as the sun wheel A is driven by the engine the carrier L, and with it the pinions B, are caused to rotate as a whole in the same direction as the sun wheel, but at a lower speed. This is the ordinary form of

epicyclic gear, and is shown diagrammatically in Figs. 13 and 14, the former showing the gear in action and the latter running idle.

To obtain the second speed both the train A, B and C and the train D, E and F are employed. The combined action of these two trains can best be followed by bearing in mind that the end to be attained is a speed intermediate between the highest speed, which is obtained by locking all the elements of the epicyclic trains together by means of the clutch, and the lowest speed, which is obtained as before described. This is effected by causing the carrier L of the first train to move faster, which end is attained by causing the pinion carrier Q of the second train, which is coupled to the annulus C of the first train, to revolve in the same direction as the carrier L by holding the sun wheel D of the second train stationary by means of the drum P. This causes the carrier Q, and with it the annulus C, to rotate in the same direction as the sun wheel A, which thus augments the speed imparted to the carrier L, and therefore the speed imparted to the driven shaft. The action of this compound gear is shown diagrammatically in Fig. 16, the elements D and F being enlarged to allow them to be shown concentric with but clear of the elements A, B and C.

To obtain the highest speed—a direct drive—the clutch is brought into action, which locks all the parts of the gear together, so that they revolve *en masse*. At all the other speeds the clutch is out of action.

To obtain the reverse the drum S to which the planet carrier R is fixed is held stationary, so that the annulus J, and with it the carrier L, and therefore the driven shaft, will be rotated in a reverse and opposite direction to the driving shaft by the action of the intermediate pinions H. The action of this gear is shown diagrammatically in Fig. 15.

Common Form of Friction Gear.—In this gear, Fig. 17, the driving disc A is mounted on a shaft V, which is in couple with the crankshaft of the engine, and the driven disc B is mounted on a shaft W, which is arranged at right angles to the axis of the driving shaft V and is in couple with the driving road wheels by means of chain and sprocket wheel or other gearing. The driven disc B is so mounted to slide on its shaft that it can be moved across the face of the driving disc A, and thus by engaging the disc at any desired position between its centre and its periphery enable any desired speed ratio to be obtained. Provision is made for drawing the driving disc A out of engagement with the driven disc B before it is moved transversely to alter the gear ratio, the driving disc A being kept up to its work—that is, in frictional driving contact with the disc B—by means of suitably arranged spring pressure.

The reverse is obtained by bringing the driven disc B over to the other side of the driving disc A, and it is usual in this form of gear to recess the driving disc in the centre so as to provide a neutral point in which motion is not imparted to the driven disc. The driving contact between the two discs is broken by drawing the driving disc A back out of engagement with the driven disc B, which is usually effected by means of a foot-pedal operating similarly to a clutch pedal, and the position of the one disc in relation to the other is varied and determined by means of a hand lever working over a notched bar or quadrant and in couple with the sliding driven disc B through the bell-crank lever C and a sliding element D, which carries a fork E that engages a groove in the boss of the sliding disc.

Cowey Friction Gear.—In this gear, Figs. 18 and 19, the driving and the driven discs engage one another face to face. The former shows the disposition of the parts when the engine is driving the transmission shaft at its highest speed, and the latter the disposition of the parts when the engine is driving the transmission shaft at a reduced speed. Between the rear face of the disc A mounted on the crankshaft V of the engine and a disc B mounted on the driven shaft W is an intermediate disc C. The rear face of the disc A is coned, and both the disc B and the intermediate disc C are dish-shaped, the former being faced on one side and the latter on both sides with a suitable friction material such as "Feredo." The disc B is carried by the driven shaft W, the front part of which is mounted in bearings in a housing D and is hollow to receive the shaft E which carries the intermediate disc C. The rear end of the driven shaft W is coupled to the propeller shaft Z by the usual universal coupling. The housing D is mounted to slide on a frame F (which consists of a pair of transversely-arranged superimposed bars), which is pivoted at one end to one of the side members Y of the frame of the chassis and is adapted at the other end to slide in or on a suitable guide G carried by the other member Y of the frame. Means are provided both for operating the frame F for the purpose of pulling the driven disc B out of engagement with the intermediate disc C so as to disengage the driving couple, and to move the housing D carrying the driven and intermediate discs and their shafts laterally in relation to the disc A, so as to cause the intermediate disc C to engage the face of the disc at a different part of its surface.

It will be seen that when the axes of the driving shaft and of the driven shaft, and therefore of the disc A and the intermediate and driven discs C and B, are co-axial, the apparatus is simply a direct-driving clutch, and that to obtain the lower speeds and the reverse it is only necessary to move the discs B and C across the face of the disc A so that the rim of the intermediate disc C will engage with a portion of the surface of the driving disc which is nearer to its centre, and obviously the nearer the driven disc is moved towards the centre of the driving disc the greater is the effective speed reduction. If the rim of the intermediate disc C is moved beyond the centre of the driving disc the direction of rotation of the driven shaft is changed, which gives the reverse drive. The housing D carrying the intermediate and driven discs C and B is coupled to the clutch pedal, so that it can be drawn backwards sufficiently to disconnect the engine from the discs by depressing the pedal, a suitable spring being employed to return the housing and keep the discs up to their work when pressure on the clutch pedal is removed. Within the housing D at the rear end of the shaft E carrying the intermediate disc C is a helical spring, which operates between the end of the shaft and the end of the hollow part of the driven shaft W. This spring, when the housing D is drawn back, separates the intermediate disc C from the driven disc, so that when the clutch pedal is depressed not only is the intermediate disc separated from the driving disc but also from the driven disc, so that there is no rubbing friction whatever between these parts. The effect of the use of the intermediate disc is to provide a complete annular clutch, which renders wear a negligible quantity. In this gear all the drives are direct, so that loss in transmission is reduced to a minimum and at all speeds is silent. Further, as any gear and the reverse can be easily and rapidly engaged at any engine or car speed a valuable emergency brake is provided.

Hall Hydraulic Gear.—In the Hall transmission, Fig. 20, three radially-arranged pumps A are employed, the plungers A^1 of which are operated through connecting-rods by a common crank B on the shaft V, which is driven by the prime mover. Three radially-arranged motors C are also employed, the pistons C^1 of which are operated through connecting rods by a crank D on a non-rotating shaft E, which is arranged eccentrically in relation to the driving shaft V. Both the pumps A and the motors C are carried in a common casing F, which is free to rotate about the axis of the driving shaft V and is coupled to the driving road wheels through suitable gearing. The cylinders of each pair of pumps and motors are connected by ports controlled by valves G and H, the valves G of the pumps being operated by an eccentric J on the driving shaft V, and the valves H of the motors by an eccentric K, which is loosely mounted on and in relation to the driving shaft V and is provided with means whereby it can be rotated through a given arc.

Fig. 12. LANCHESTER GEAR.

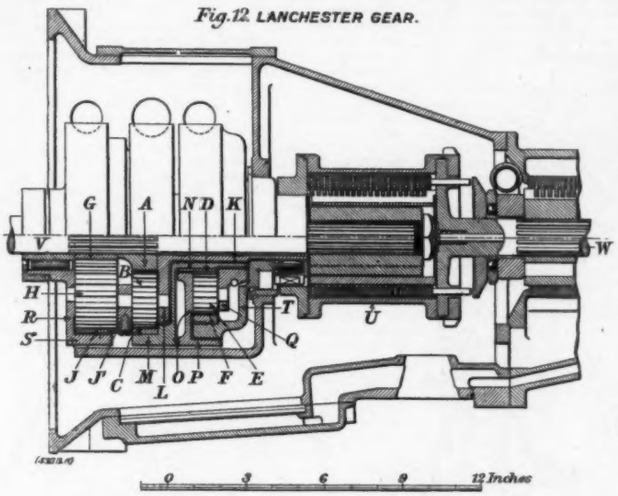


Fig. 13 to 16. DIAGRAMS OF LANCHESTER GEAR

Fig. 13.

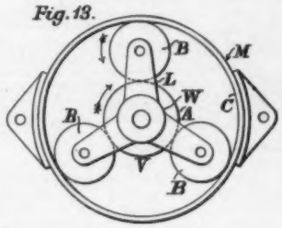


Fig. 14.

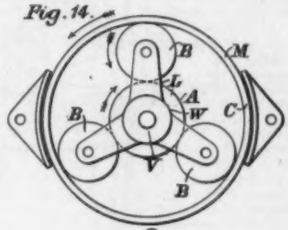


Fig. 15.

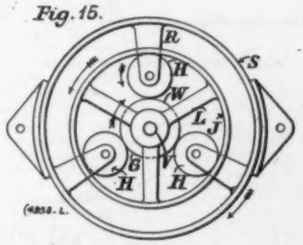


Fig. 16.

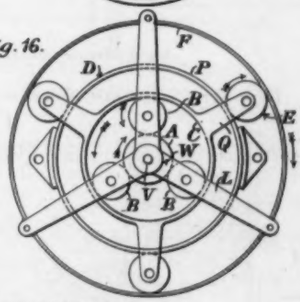
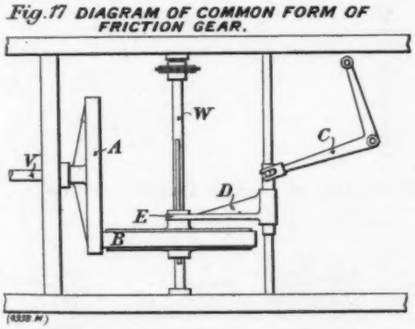


Fig. 17 DIAGRAM OF COMMON FORM OF FRICTION GEAR.



DIAGRAMS OF COWEY FRICTION GEAR

Fig. 18.

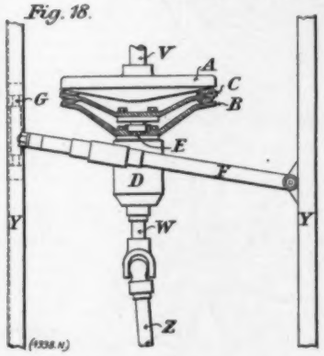
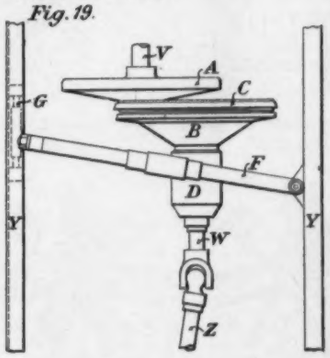


Fig. 19.



The shaft E, although non-rotating, is capable of a limited amount of rotation—through the worm L and the worm wheel M—in order to adjust the eccentricity of the crank K. The shaft E carrying the crank D is carried in an eccentric bush or bearing N, the eccentricity of which is equal to the throw of the crank D, so that when the crank is turned so that its greatest throw coincides with the greatest eccentricity of the bush or bearing N the crank will be concentric with the shaft V and will then act merely as a fixed axle and impart no movement to the pistons C^1 of the motors C as the casing F rotates. The eccentric K on the driving shaft V, which operates the valves H of the motors, has an extension O which is toothed internally and engages a spur pinion P carried on a shaft Q, which passes centrally through a hole in the shaft E. The shaft Q is provided with suitable means of rotation exterior to the casing F, so that the position of the eccentric K can be altered in relation to the crank D. By this means, in a manner similar to that of the well-known form of loose eccentric reversal employed in marine engines, the direction of rotation of the casing F can be reversed when required. The whole of the spaces, passages and cylinders of the casing F are filled with oil, which is constantly pumped by the pumps A through the valves G and H to the motors C, the capacity of which exceeds that of the pumps.

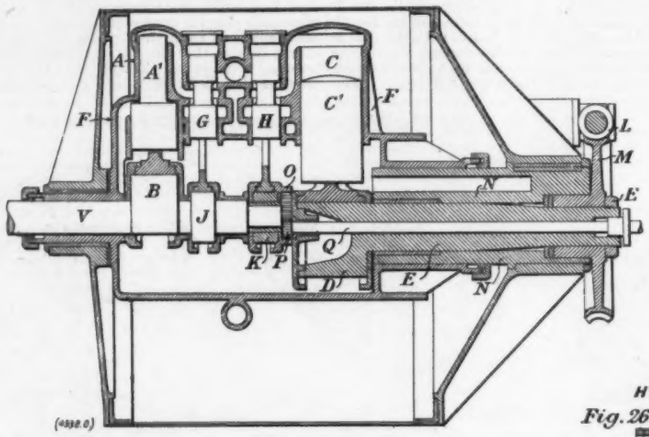
The action of the apparatus is as follows:—Upon motion being imparted to the driving shaft V, the pumps A operate to pump oil into the back ends of the cylinders of the motors C, which thereby impart rotary motion to the casing F, the ratio of speed between the driving shaft and the casing being determined by varying the centre of the crank operating the pistons of the motors with respect to the axis of the driving shaft. When the cylinders of the motors are working to their full capacity the greatest reduction of speed is obtained, and inversely when they are working at their lowest capacity the highest speed is obtained, the casing F then rotating at the same speed as the driving shaft V. If, as in the construction illustrated, the capacity of the motor cylinders is four times that of the pump cylinders, when the crank of the motors is in the position to impart the greatest amount of movement to the pistons of the motors it will take four strokes of the plungers of the pumps to fill the cylinders of the motors with oil, and consequently the shaft V will have rotated four times during the time the pumps have by filling the motors caused the casing F to rotate once, but as in normal working shaft V and the casing F rotated in the same direction one revolution of the pump shaft is lost for each revolution of the casing, so that the shaft V is geared down in relation to the casing F in proportion of 5 to 1. As before stated, when the crank D is concentric with the shaft V there is no movement of the pistons of the motors, and consequently the whole apparatus is carried round at the same speed as the shaft V, and the highest speed of rotation is imparted to the casing F. In this condition there is no circulation of the fluid in the apparatus, and except for the connecting rods of the motors turning upon the crank D and the rods of the valves H moving upon the eccentric, there is no relative movement of the various parts of the mechanism. It will be understood that the two positions of the crank D before described are the two extremes, and that any intermediate position of the crank and, consequently variation of the proportions of speed and power of the whole apparatus, can be obtained by rotating the crank D.

Compayne Hydraulic Gear.—The essential feature of the Compayne transmission is the Hele-Shaw pump, Figs. 21 and 22, which by reason of its construction can not only be run at a high speed without vibrations, but has a high degree of efficiency. The construction and action of this pump—which is of the rotary plunger type with a plurality of cylinders—will best be understood by reference to Figs. 23, 24 and 25, which are diagrammatic sections through the pump at right angles to its axis. The cylinders A (of which there are seven in the construction shown) are formed in one block with a sleeve which is mounted on a fixed stub axle B, this sleeve being coupled to a shaft S which is driven by the prime mover. The pistons C carry gudgeon pins D, which pass through slots in the cylinders and engage with slipper pieces E which fit in two opposed grooves in a drum F, which is mounted in ball bearings to rotate in a housing G. The grooves in the drum F form paths for the gudgeon pins, and the drum F operates as a floating ring, the action and operation of which in relation to the pistons is that of a series of connecting rods. The housing G is mounted to slide transversely across the casing X in suitable guides. By displacing this housing in the casing X in relation to the stub axle B on either side of its vertical centre line, that is to say, along a horizontal line *xx* passing through the centre of said axle, the eccentricity of the path of the gudgeon pins with respect to the cylinders can be varied for the purpose of varying the stroke of the pistons, and therefore the output of the pump as a whole. As the acceleration of the slipper pieces and pistons above the centre line *xx* is balanced by the retardation of similar parts below the centre line, all the inertia forces are balanced.

The drum F is kept full of oil by centrifugal action, and no oil is allowed to accumulate in the casing X, whereby all churning of the oil is avoided. In the stub axle B, about which the cylinder block revolves, are two ports or groups of ports, H and K, with which ports in the bases of the cylinders A coincide as they revolve, said ports being in communication with similar ports or groups of ports, H^1 and K^1, at one end of the axle B exterior to the casing X by means of suitable passages. When the block of cylinders revolves, the floating ring F revolves with it, as the resistance of the slipper pieces E is greater than that of the ball bearings carrying it. In the central position the slipper pieces have no movement, and in any other positions they only move to and fro to an extent directly proportional to the stroke of the pistons. If the cylinders are rotated in the direction of the arrows, and the path of the gudgeon pins is concentric with the axle B, as in Fig. 24, no motion is imparted to the pistons, and therefore the pump is inoperative. If the path of the gudgeon pins is moved to the left, as shown in Fig. 23, the pistons as they move above the centre line *xx* move outwardly and therefore tend to create a vacuum, so that the oil is forced into the cylinders either by atmospheric pressure or by an artificial pressure in a supply tank through the ports H^1 and H, while the pistons as they move below the centre line *xx* move inwardly and discharge the oil from the cylinders through the ports K and K^1, the ports H^1 and K^1 being connected by suitable piping to the hydraulic motors. If the path of the gudgeon pins is moved to the right, as shown in Fig. 25, the pistons move outwardly when moving below the centre line *xx*, and inwardly when moving above said line, so that the flow of the oil is reversed without altering the direction of rotation of the cylinders, the ports K^1 and K becoming the suction ports and the ports H and H^1 the delivery ports. In moving from the position of maximum delivery on one side to that on the other side, the discharge is gradually reduced until the central position is reached, when the delivery ceases, after which it again increases to the maximum with the flow in the opposite direction, the change from full forward to full reverse discharge being made without shock, the flow at all times being proportional to the eccentricity of the path of the gudgeon pins.

The hydraulic motor, Figs. 26 and 27, is of a similar

Fig. 20. DIAGRAM OF HALL HYDRAULIC GEAR.



Figs 21 and 22. HELE-SHAW PUMP. COMPAYNE HYDRAULIC GEAR

Fig. 21.

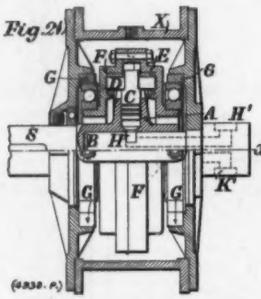
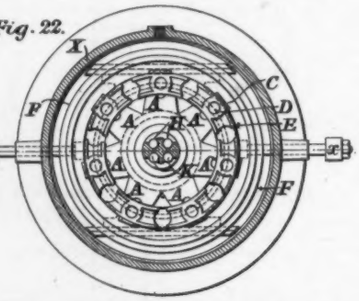


Fig. 22.



DIAGRAMS OF HELE-SHAW PUMP. COMPAYNE HYDRAULIC GEAR.

Fig. 23. *Fig. 24.* *Fig. 25.*

HYDRAULIC MOTOR. COMPAYNE HYDRAULIC GEAR.

Fig. 26.

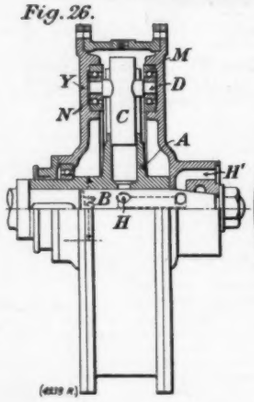


Fig. 27.

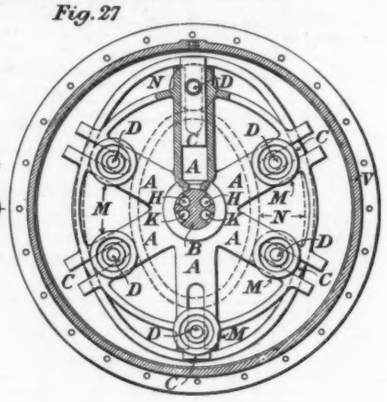
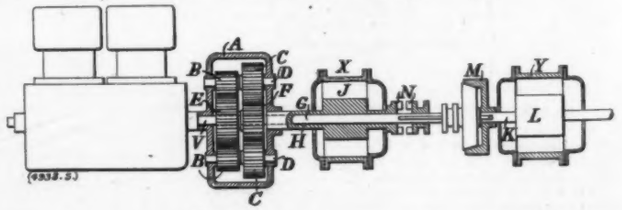


Fig. 28. DIAGRAM OF THOMAS ELECTRIC SYSTEM



construction to the pump, but is of the constant-stroke type and works inversely. The novel feature of the motor is the employment of a cam as a track for rollers carried by the gudgeon pins. Two motors are usually employed, arranged either one in each road wheel or both mounted on the chassis and each driving one of the road wheels by means of chain or other gearing. The gudgeon pins D carried by the pistons C carry ball-bearing rollers M at their ends, which travel within a double cam M formed in or carried by the casing Y. Owing to the shape of the cam, the pistons make two strokes per revolution. This gives a complete balance of the working parts, an absolute and uniform turning movement, and obviates any shock in the system. By arranging the cam and the valve shaft so that they can both rotate at relatively different speeds, and making the cam of a corrugated or wavy form, a single revolution of the motor can be obtained from any desired number of strokes of the pistons of the pump. This enables a very great turning effort to be secured without unduly increasing the proportions of the motor.

Pieper Electric System.—In the Pieper, or Auto-Mixte, system, which is practically the same as the earlier British system of Farrow, a shunt-wound dynamo is mounted on a shaft which couples the engine with the road wheels through a magnetic clutch and suitable transmission gearing. The dynamo is connected through a controller with a battery of accumulators, and works either as a motor or a dynamo, according as its E.M.F. is inferior or superior to that of the battery. The dynamo is fitted with commutating poles, the windings of which are connected in series with the armature, thus ensuring good commutation with heavy currents and with a weak main field. The battery, although primarily employed for assisting in propulsion, can also be used for starting the engine and for ignition purposes. The supply of explosive mixture to the engine is controlled by the demand for current from the accumulators through a differentially-wound solenoid, so that during starting and the period of extra effort the discharging current traversing its series winding decreases the magnetism produced by the shunt winding, which in turn increases the supply of mixture, and thus compels the engine to give its maximum power for a given number of revolutions per minute. When the dynamo is charging the cells, the action of the series winding assists that of the shunt winding and tends to close the throttle. When the power of the engine is below that required, the battery automatically supplies energy to the dynamo, which then operates as a motor. When the power of the engine is in excess of that required for traction, or when the kinetic energy of the car can be recuperated, that is, when the car is slowing down or is running on a down-gradient, the dynamo works automatically as a generator and charges the battery. When the vehicle is on an up-gradient, and the torque on the road wheels becomes greater than the turning moment of the engine, the speed of the latter diminishes and the voltage of the dynamo falls until it becomes less than that of the battery. The battery then discharges into the dynamo, and thus produces torque, which assists that of the engine until it balances the resisting torque of the engine. On a down-gradient, if the resisting couple is less than the turning moment of the engine, the speed of the latter tends to increase, and the voltage of the battery rises, so that the dynamo begins to charge the battery. As this charging current passes through the regulator the rate of admission of mixture to the engine is reduced to a minimum, and the torque of the engine becomes zero.

Stevens Electric System.—In the Stevens system a shunt-wound generator of the interpolar type producing a continuous current is driven directly by the engine, and a series-wound electric motor is coupled to the transmission shaft of the vehicle, a controller box and a shunt resistance for the generator fields being provided. The generator, which is capable of an output of from 1 to 36 kilowatts at a speed varying from 350 to 1,400 revolutions per minute at a voltage varying from 0 to 300, is designed with a falling characteristic, so that any increase in the demand for current when the engine is fully loaded is accompanied by a corresponding reduction in voltage. The output in kilowatts at any speed is proportional to the power exerted by the engine, but the volts and amperes vary over a large range, according to the gradient of the road, the speed, or the degree of acceleration required. The amperes required by the series-wound motor are approximately proportional to the torque on the transmission shaft, and the speed of the motor is to a smaller degree proportional to the voltage of the supply. Consequently, when the vehicle is running on a level road the demand for current is small, but on up-gradients it increases, with a corresponding decrease in voltage, which results in a slower speed with increased torque. This change takes place automatically. The excitation of the generator ceases automatically when the engine speed falls below 250 revolutions per minute.

In ordinary running on the level, or on slight up-gradients, the speed of the vehicle is entirely regulated by controlling the speed of the engine by means of the usual gas throttle-valve; but on stiff up-gradients, heavy roads, or under other conditions requiring greater power, the shunt resistance is employed to allow of increased engine speed. The controller has three positions—forward, neutral and reverse. As the generator ceases to excite at 250 revolutions per minute of the engine, no electrical circuits are required to be made or broken in driving, even when stopping in traffic, as by reducing the speed of the engine to 250 revolutions per minute, or less, by means of the throttle-valve, the generation of current is stopped, and therefore no power is transmitted to the road wheels. Owing to the interpolar construction of the generator, sparkless commutation is ensured, and as the main circuit is never broken during driving, no sparking occurs at the contacts. At starting the electric motor demands a large current to develop the necessary torque for starting, which the dynamo supplies at a low voltage, and as the motor speeds up it automatically demands less current, which is supplied by the generator at an increased voltage. In other words, the voltage of the generator varies in inverse ratio with the amperes output, therefore the power required to drive the motor can never exceed a predetermined maximum, which is arranged to correspond to the maximum power of the engine.

Germain Electric System.—In the Germain system, which of all the systems most nearly approaches the purely electrical change-speed gear, the electrical transmission is only employed while the vehicle is being accelerated to such a speed that the prime mover can deal with the load direct, at which time it is coupled directly to the transmission mechanism through a magnetic clutch. Two series-wound dynamos are employed. The field magnets of one dynamo are fixed on the crankshaft of the engine and rotate with it and incidentally take the place of the flywheel, and the field magnets of the other dynamos are permanently fixed. The armatures of the two dynamos—each of which has its own commutator—are mounted on a shaft which is arranged in axial alignment with the crankshaft of the engine and is connected to the road wheels by suitable transmission mechanism. The dynamo coupled to the engine acts either as a dynamo or as a magnetic clutch, and the other dynamo acts for the most part as a motor, but is also used as a dynamo for "braking" purposes.

Variations of speed of the car are effected entirely by a controller, which makes the necessary electric connections between the dynamo, the motor, and a variable resistance coil. Assuming that the engine has been started and that the car is at rest, the electric circuit is open throughout, so that no current is generated, and the armature of the dynamo remains stationary. To start the car the controller is operated to connect the dynamo in series direct to the motor, whereupon the car will travel at a speed dependent on the work it is called upon to do. The power imparted to the driving wheels of the vehicle is now partly derived from the magnetic pull of the field magnets of the dynamo on its armature and partly from the pull of the motor. The faster the vehicle runs the more nearly the speed of the armature of the dynamo corresponds with the speed of the field magnets, and consequently the amount of current supplied by the dynamo to the motor becomes less and thereby reduces its speed and the amount of work it will perform. The reduction of current, however, also affects the pull of the field magnets of the dynamo on its armature, on account of the magnetism of both being reduced. On the other hand, the slower the vehicle runs the greater is the relative speed of the armature and field magnets of the dynamo, with the result that the clutch effect between these two parts is increased and the power of the motor becomes greater. To increase the speed of the vehicle, the controller is operated to introduce the resistance across the field magnets of the motor, which increases the speed of the motor and increases the current flowing through the main circuit and therefore also the magnetic pull of the dynamo. By reducing the value of the resistance through the action of the controller the speed of the vehicle can be gradually increased until the field magnets of the motor are completely short-circuited. When this result is attained there is only sufficient relative movement between the armature and field magnets of the dynamo to generate the necessary current to magnetise these parts so that they operate as a clutch. To enable the mechanism to be used as a brake the controller causes the circuit to be so altered that the functions of the dynamo and the motor are reversed.

Thomas Electric System.—In the Thomas system, which is diagrammatically shown in Fig. 28, the essential feature is the introduction of a planetary gearing, and it can best be described as an epicyclic gear in which the brake employed to retard or stop the rotation of one of the elements of the train takes the form of a resistance set up in an electrical machine, and in which the current generated in the said electrical machine is employed to augment the power of the prime mover through a suitable motor. In this system three essentials element are employed, namely, a planetary gear and two series-wound electrical machines. The casing A of the planetary gear fixed on the crank shaft V takes the place of the flywheel of the engine. The planet pinions B and C, of which there are two or more groups, are of different sizes, each group being mounted on a shaft D carried by the casing A. These planet pinions gear with two sun-wheels E and F—also of different sizes—which are fixed respectively on an extension shaft G of the crankshaft V and on the end of a hollow shaft H which fits over the extension shaft G. On the shaft H is mounted the armature J of one of the electrical machines X, and on a shaft K, which is arranged in axial alignment with the shaft G, is mounted the armature L of the other electrical machine Y. The shaft K is coupled to the shaft G by means of a friction clutch M, and a couple in the form of a positive clutch N is provided between the shaft G and the shaft H. The two electrical machines X and Y are connected in series. There are thus two paths through which the power from the engine can be transmitted to the road wheels, the one a mechanical one through the pinion E and the shafts G and K, and the other an electrical path through the pinion F and the two electrical machines X and Y. Assuming a given rotation of the casing A, as the pinion E is larger than the pinion F, the pinion F and with it the shaft H and the armature J will tend to rotate backwards, and the pinion E and with it the shaft G and the armature L will tend to rotate forwards at speeds depending on their relative resistance to motion, and thus if the speed of the engine is constant the speed of the shaft G will vary as the speed of the shaft H, and since the speed of H depends upon its resistance to motion and therefore on the load of the electrical machine Y, the speed of G can be varied by varying the power transmitted electrically between the armatures L and J, which is obtained by varying the strength of the fields of the two electrical machines by means of a suitable controller.

The operation of this transmission is as follows: before starting there is no electrical connection between the two electrical machines X and Y, so that the shaft H and the pinion F rotate backwards while the pinion E remains stationary. To start the vehicle, current is taken from the electrical machine X to the electrical machine Y. This has a double effect upon the shaft G. The current transmitted to the armature L exerts a torque on the shaft G, and the loading of the armature L with this current, by decreasing the speed of the pinion F and the shaft H, causes the pinion E and the shaft G to rotate. A part of the torque is thus transmitted electrically and a part mechanically. As the armature J of the electric machine X is gradually decreased in speed the vehicle increases in speed until the shaft H, and with it the armature J of the electrical machine X, practically comes to rest. Up to this point the electrical machine X has been acting as a dynamo and the electrical machine Y as a motor. Both machines now change their functions, power being transmitted from Y to X. Owing to the shaft H being forced to rotate against and in the same direction as the engine, the speed of the shaft G still further increases. The speed of the shaft H increases more rapidly than that of the shaft G, due to the gear ratio on the planetary gear, until finally they both travel at the same speed. The coupling N is now engaged so that the engine drives direct through to the transmission shaft. To obtain the reverse, the coupling N is engaged and the clutch M disengaged. The armature J of the electrical machine X is then rotated by the engine and the current generated by the machine is transmitted to the electrical machine Y, which is given a reverse field. The electrical machine X—connected up as a shunt machine—may, when the engine is driving direct on to the transmission shaft, be employed to charge a set of accumulators, which can be used through the medium of the same electrical machine to start the engine.

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AMERICAN COTTON CONSUMPTION.—The consumption of cotton in the United States broke all records in the twelve months ended July 31. The returns for the year place the consumption at 6,397,613 bales, as compared with 5,597,362 bales in 1914-15, showing a gain of 14 per cent. over the previous high record. In addition to this, there were 880,916 bales of linters used this year, or more than double the quantity used in the previous year, The large gain in mill consumption was, of course, attributable to the steadily growing increase in the use of American cotton in the country of its origin, and especially in the South; but the great increase in linters consumption was due to the demand for a short-staple fibre in the manufacture of explosives. The annexed table shows the number of active spindles, the annual mill consumption, and the quantity of linters used in the American Union in the five years ended July, 1916, inclusive:—

Year.	Spindles.	Mill Consumption.	Linters Used.
1912 ..	30,578,528	5,129,346	288,237
1913 ..	31,519,766	5,483,321	305,089
1914 ..	32,107,572	5,577,408	307,325
1915 ..	31,964,235	5,597,362	411,845
1916 ..	32,905,883	6,397,613	880,916

The whole number of spindles in the United States is 33,333,176, or only 527,293 spindles in excess of the number of spindles active in 1915-16. The number of spindles in the principal cotton-manufacturing States is returned as follows:—Massachusetts, 10,896,774; South Carolina, 4,735,193; North Carolina, 3,988,098; Rhode Island, 2,552,765; Georgia, 2,259,855; New Hampshire, 1,455,282; Connecticut, 1,343,573; Alabama, 1,111,560; and Maine, 1,090,006. No other State reached 1,000,000 spindles.

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MINING, METALLURGY, AND METAL WORKING.

17,877/15. W. Pickersgill, F. Pickersgill, and F. Pickersgill, Keighley. Power Hammers. (7 *Figs.*) December 22, 1915.—This invention relates to power hammers for use in the swaging or clinching of the covering plates at the bases of shells. In accordance with this invention, the base B of the power hammer is arranged so that a rotary holding device 11 may be mounted upon it. A worm wheel 12 is secured to a part 13 forming the support for the rotary anvil 11. A worm driven from the main shaft 3 engages the worm 12 and transmits motion to the anvil 11 at the desired rate of speed. The driving pulley 9 forms a clutch

Fig. 1.

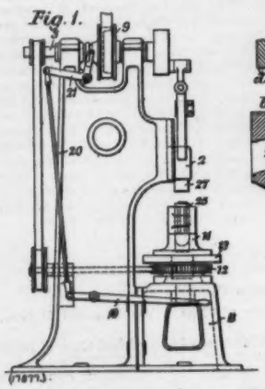


Fig. 2.

Fig. 3.

which the attendant may, by the hand lever 19, connecting rod 20 and fork lever 21, actuate so that during the time that the head 2 is being reciprocated the anvil 11 will be rotated beneath same. The reciprocating movements of the head 2 forces the swaging tool 27 against the tapered projection *b*, on the end of the shell 25, and as the shell rotates the swaging action of the parts is carried out so that the projecting portion *b* is caused firstly to be bent over and afterwards is forced or squeezed into the cavity. The swaging tool 27 is made with radial projections *d*, the swaging surfaces of which are curved. (*Accepted November* 1, 1916.)

PUMPS.

101,844. V. Moller, Svendborg, Denmark. Diaphragm Pumps. (2 *Figs.*) June 1, 1916.—The invention relates to diaphragm pumps of the kind in which the strokes are alternately suction and pressure strokes. The casing of the pump comprises

Fig. 1.

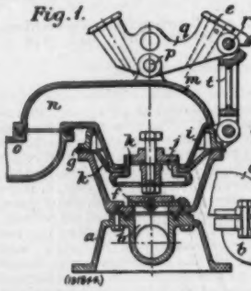
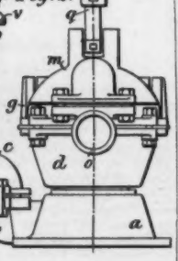


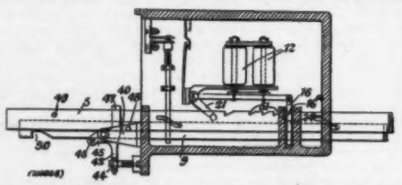
Fig. 2.



a supporting foot *a*, a pump chamber *d* and a pump body *i*. The foot is provided with an elbow pipe *b* connected to the suction pipe *c*. The pump chamber is provided at the bottom with an opening controlled by a suction valve *f*, which only opens upwardly to the interior of the chamber *d*. Between the pump chamber *d* and the pump body an annular diaphragm *h* is arranged. The outer edge of the diaphragm *h* is fixed between the ring-shaped upper edge of the chamber *d* and a ring *g* bolted to said edge. The inner edge of the diaphragm is fixed between the lower edge of the pump body *i* and the valve seat *j* of the pressure valve *k*, which valve seat is mounted in the pump body, in the bottom of which the pressure valve is arranged. The pump body has a dome-shaped cover *m*, which terminates in a pipe-shaped extension *n*, to which is fixed a nozzle *o*. The pump body is suspended on a pin *p* carried by a knee *q*, one end of which is pivotally connected at *r* to the upper end of a pump lever *t* pivoted at *s*. Normally the edge *u* of the pump body rests on the upper edge of the ring *g*. The knee *q* is provided with holes *a*, into which hand levers for the two men operating the pump are inserted. If the pump lever *t* is moved to the right from the position shown in Fig. 1, the bolt *r* will move to the right and downwards, thereby causing the knee *q* to turn on the bolt *r* and to lift the pin *p* vertically, so that the pump body *i* and the parts fixed to it are moved vertically upwards. The upward movement is limited by an extension *v* of the knee *q*, which meets an extension of the pump lever and prevents further movement of the knee *q*. During the up-stroke (suction stroke) of the pump body the pressure valve *k* is closed, while the suction valve *f* opens and allows the liquid to enter the pump chamber *d*. The inner edge of the diaphragm *h* is lifted with the pump body. When the suction stroke is performed the pump lever *t* is returned to the position shown in Fig. 1, and of course the pump body is moved downwards until its edge *u* meets the upper edge of the ring *g*. During this movement (the pressure stroke) the suction valve *f* is closed while the pressure valve *k* is open, and the diaphragm *h*, the inner edge of which is moving downwards, forces the liquid up through the valve *k* and out of the nozzle *o*. (*Accepted November* 1, 1916.)

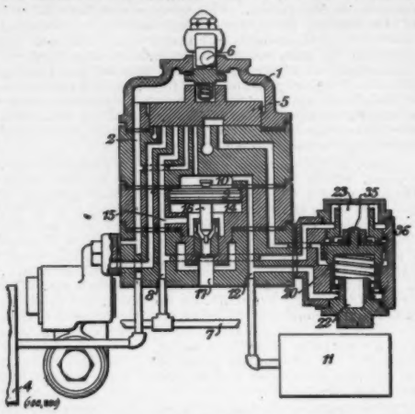
RAILWAYS AND TRAMWAYS.

101,608. J. P. O'Donnell and H. S. Knox, London. Railway Signalling Apparatus. (2 *Figs.*) June 17, 1916.—This invention provides means whereby it is ensured that a lever which has been operated to place a signal to safety and put back its frame sufficiently far to place the signal to danger, but not fully home, cannot be again operated to place the signal again to safety until the catch rod is placed fully down, the lever stroke being first completed. 40 is a bracket on the casing of the lock, and in this bracket a three-armed lever is pivotally mounted. One arm 42 of the lever carries a contact maker adapted to make contact in the position shown, with contacts 44 included in the energising circuit of the lock magnet 12. Another arm is provided with a pin 46 adapted to engage the under surface of the catch rod tapper 9, and arm 47 is arranged as a counterbalance weight, the lever having a bias normally tending to carry the contact out of contact with the contacts 44, but insufficient to overcome the grip of the contacts 44 of the contact maker. Assuming the catch rod tappet 9 to have been raised and the magnet 12 being energised, the lever to be unlocked on a pin 49 engaging the third arm 47 of the three-armed lever in the movement of the tappet 5 when the lever is operated to put the signal to safety, the three-armed lever will be turned and the contact maker carried away from the contact 44, the arm 47 of the three-armed lever then resting against stop 48 and the pin 46 against the undersides of the tappets. The contact maker will now be clear of the contacts 44 and the circuit of the magnet 12 will be broken. On the catch handle being released



with the lever in its reverse position (*i.e.*, signal at safety) the position of the three-armed lever will be unaffected as the notch 50 will take about the pin 46. Assuming that the catch rod tappet is now raised and the lever put back in the frame sufficiently far to place the signal to danger, but not fully home with the catch rod down, the three-armed lever will, owing to its bias, remain in its turned or operated position with the contacts 44 broken and the magnet 12 de-energised. The magnet 12 will be in its raised position, owing to crank-arm 21 resting on the upper surface of tappet 9, which is in its raised position, but as the magnet is now de-energised the lock 16 is free to drop (*i.e.*, is not supported by the magnet) and is resting on tappet 5 either in one of the notches 51 or between them. If an attempt be now made to replace the lever in its reverse position (*i.e.*, to again place the signal to safety) without first completing its stroke and lowering the catch rod, such attempt will be frustrated, as the bevelled locking part 16a of the lock 16 will be in or will enter one or other of the notches 51, the vertical face of which, by engaging the vertical face of the lock, will prevent movement towards the reverse position of the lever. Assuming now that the lever has been put fully home but the catch rod has not been lowered, the circuit of the magnet 12 will be broken at contacts 44 as the three-armed lever will remain in its turned or operated position, and the lever will be locked by the lock 16 having entered the normal position, locking notch 14 in the tappet 5. The three-armed lever can only be restored to the position shown, and the circuit thus be remade at contacts 44, by the lowering of the catch rod and the catch rod tappet 9. (*Accepted October* 11, 1916.)

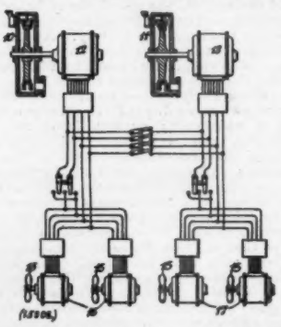
100,881. The Westinghouse Brake Company, Limited, London. Braking Apparatus. (2 *Figs.*) July 13, 1915.—This invention relates to fluid pressure braking apparatus for trains, and it has for its subject a brake-valve device for controlling the brakes where applications of the brakes are effected by reducing the train-pipe pressure. The brake-valve device comprises a sectional casing 1 having the usual rotary valve chamber connected by passage 2 with the main reservoir 4, and containing rotary valve 5, operated by the handle 6, while the train pipe 7 communicates with a passage 8 leading to the rotary valve seat. The brake valve casing also contains the usual equalising piston 9, subject on one side to the pressure in chamber 10, which is open to the equalising reservoir 11 through passage 12, and on the opposite side to the pressure in chamber 14, which is connected to the train pipe 7 through passages 15 and 8. The equalising piston 9 operates the usual discharge valve 16 for controlling the venting of fluid under pressure from the train pipe 7 to the atmosphere through the exhaust port 17. According to the present invention, there is provided a differential



piston valve 35, adapted to control communication from the equalising reservoir 11 to the rotary valve seat. The piston is contained in a casing which may be secured to the brake-valve casing 1 as shown and is adapted to seat against a seat 36 in one position and against another seat 20 in its opposite position. The piston valve 35 is subject on one side to the pressure of a coil spring and to the fluid under pressure in a chamber 22, which is constantly open to the equalising reservoir 11, and on the opposite side to the train-pipe pressure supplied to chamber 23, so that train-pipe pressure normally acts on a restricted area of the piston in chamber 23, but is adapted to have the full area exposed when the piston moves from its seat 36. (*Accepted October* 11, 1916.)

SHIPS AND NAUTICAL APPLIANCES.

15,008/15. The British Thomson-Houston Company, Limited, London. (*General Electric Company, Schenectady, U.S.A.*). **Ship Propulsion.** (4 *Figs.*) October 23, 1915.—The drawing diagrammatically illustrates a system of electric ship propulsion having two generating units. These units are shown as turbo-alternators, comprising turbines 10 and 11 directly coupled to alternating current generators 12 and 13 respectively. The generating units are preferably located in separate engine rooms, and the apparatus of the system may in general be similar to that described in Specification No. 2,841 of 1915. The four propellers 15 of the ship are each driven by an induction motor. For full-speed operation of the ship the two motors 16 are electrically connected to the generator 12, while the two motors 17



are electrically connected to the other generator 13. When the ship operates at low speed the capacity of one generator is sufficient and all four motors are then operated in parallel from either one of the generators. The arrangement is such that the connections of the armature circuits can be changed so that the generator operates with a different characteristic curve when delivering energy to all of the propeller-driving motors than when delivering energy to only some of such motors. This result may be attained by providing the generator with a plurality of armature circuits and so altering the connections of these circuits that the generator operates on substantially the same point of its characteristic curve when delivering electric energy to either of two different combinations of propeller-driving motors. (*Accepted November* 1, 1916.)

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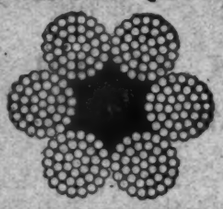
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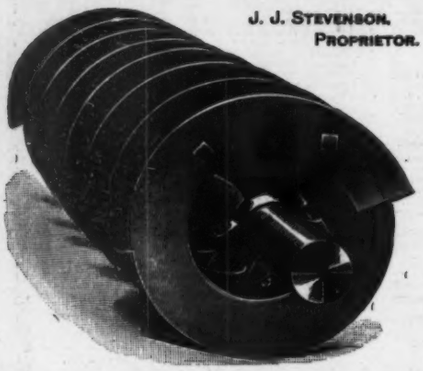

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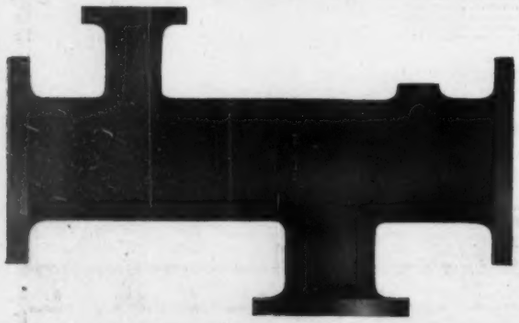

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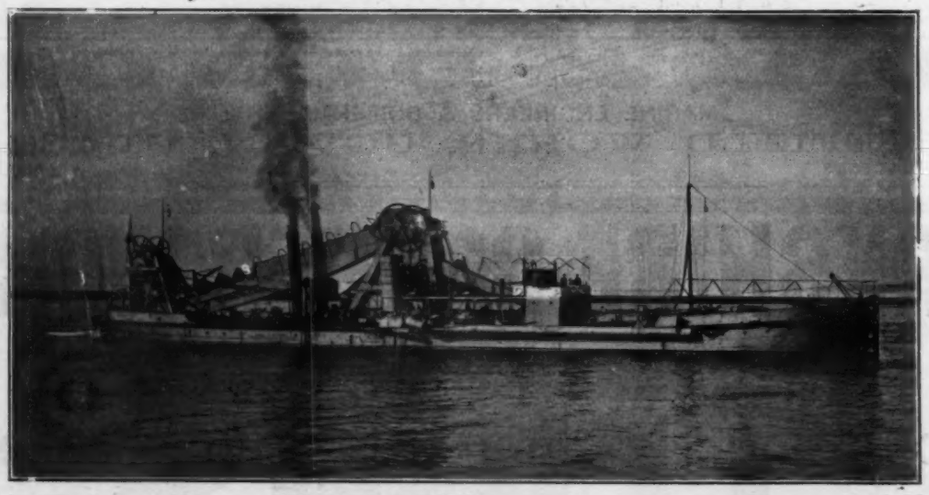

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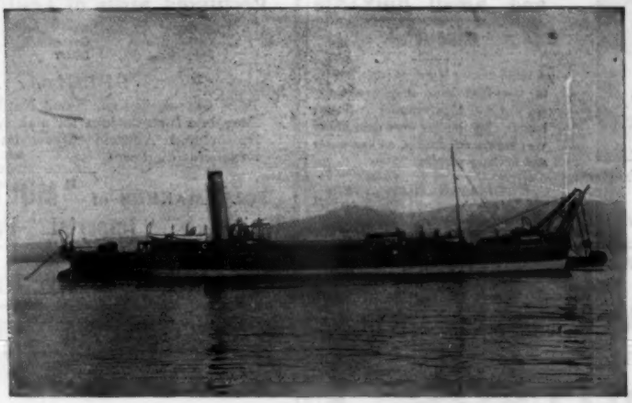

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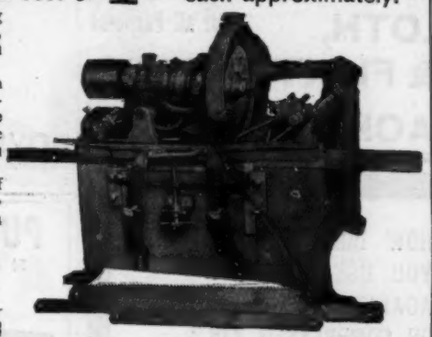

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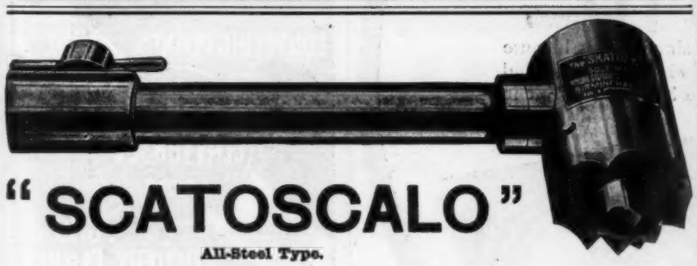

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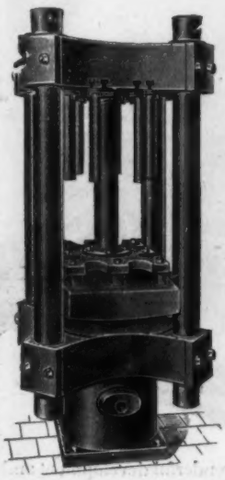

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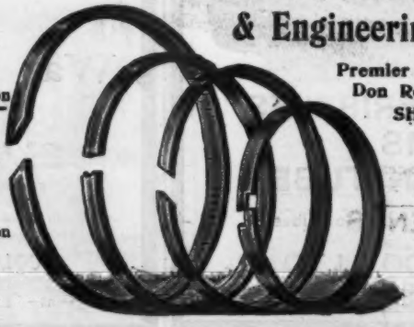

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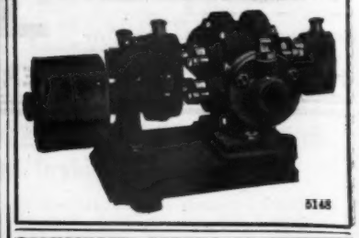

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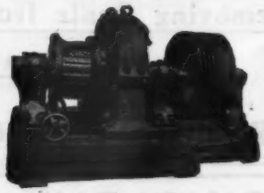

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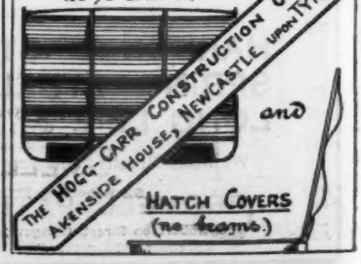

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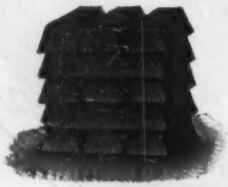

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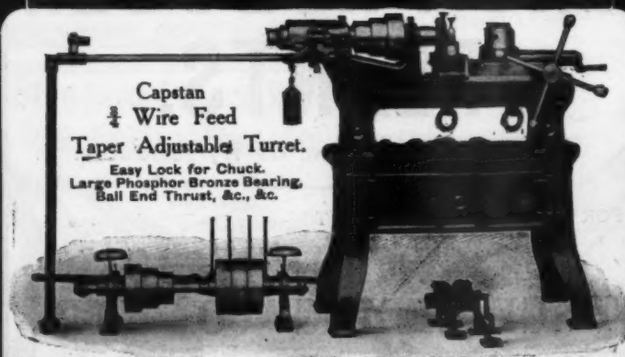

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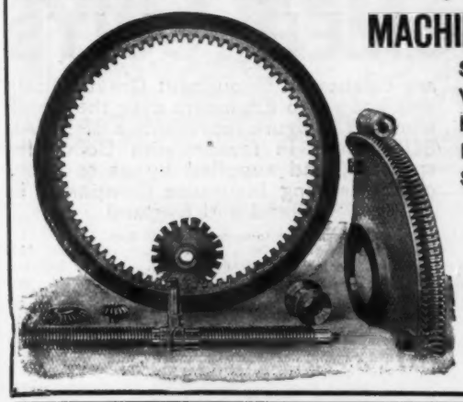

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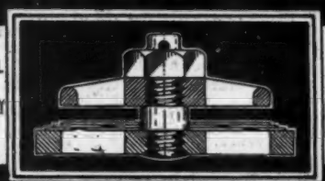

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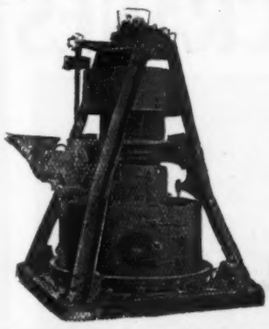

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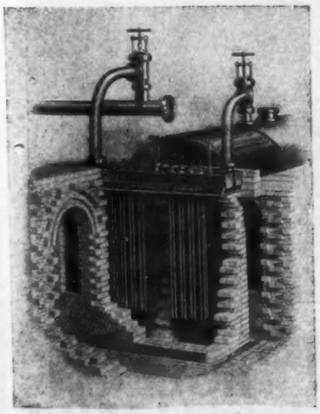

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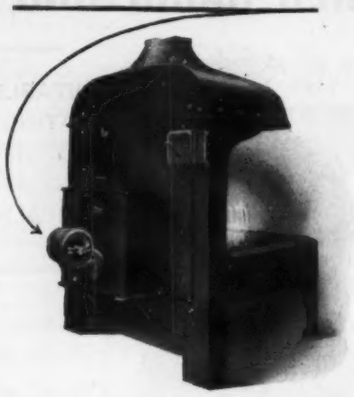

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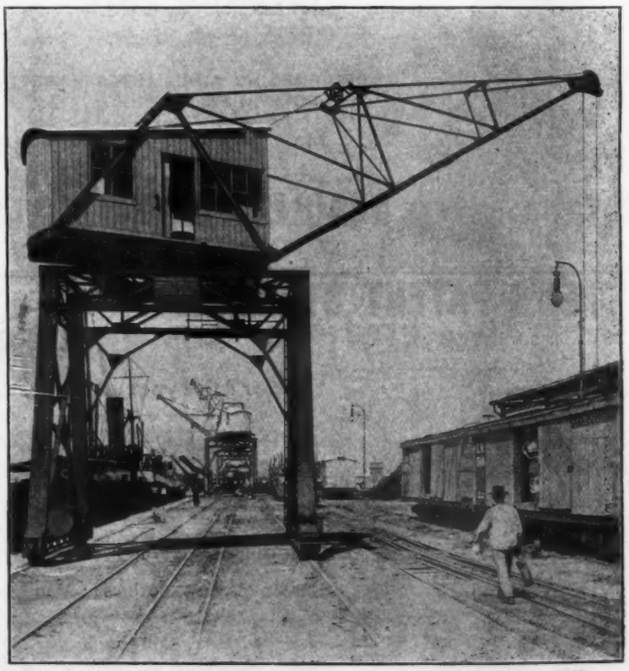

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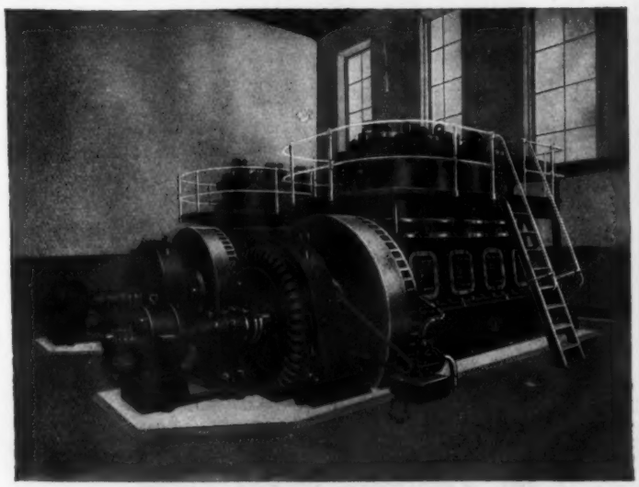

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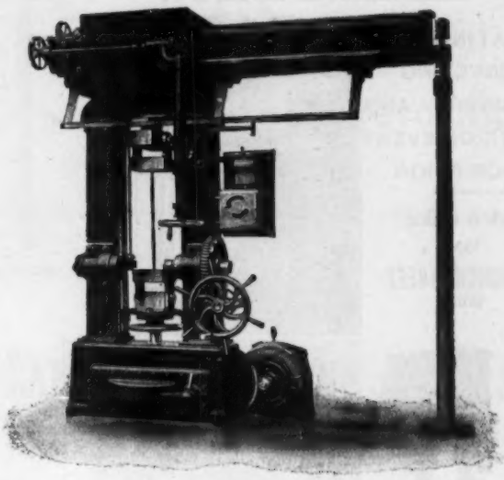

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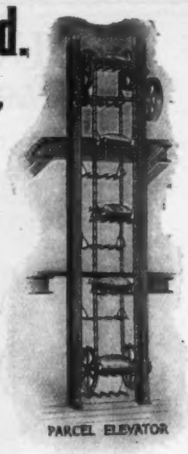
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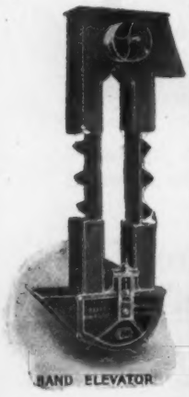
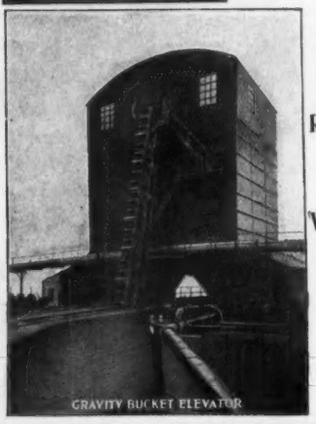

BAND ELEVATOR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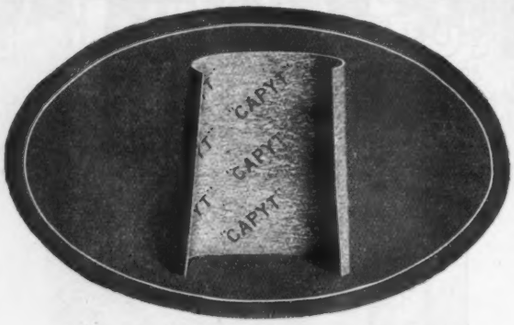

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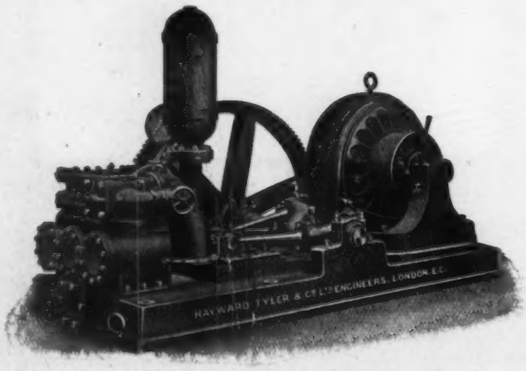

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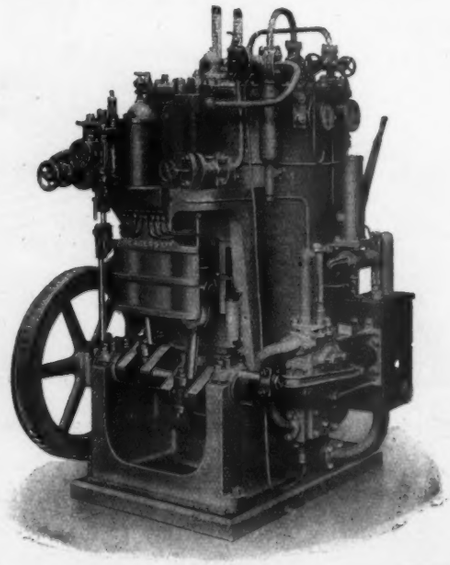

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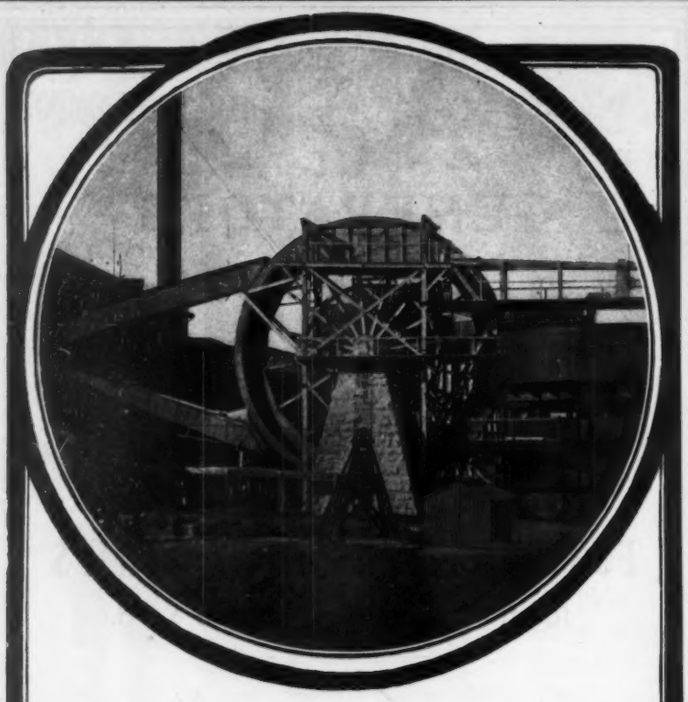

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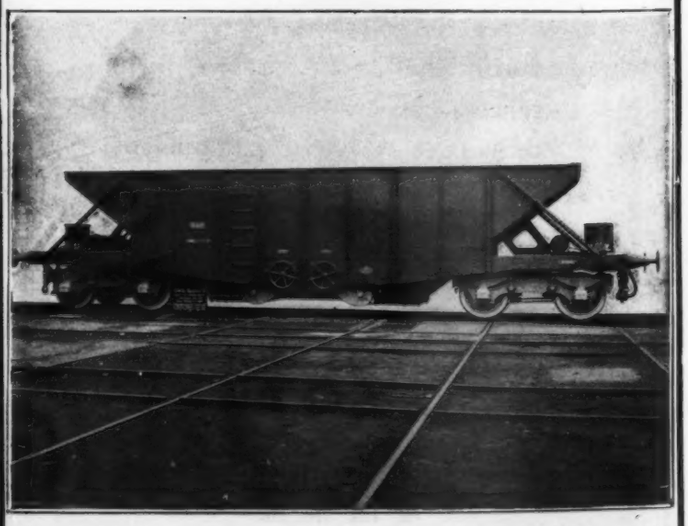

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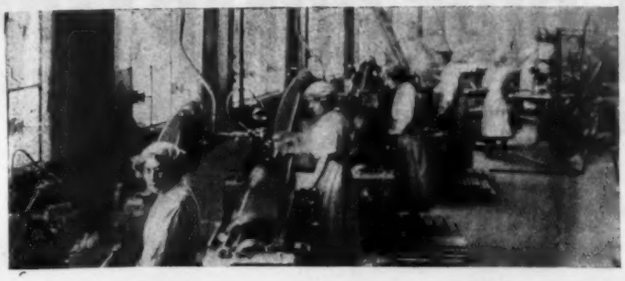

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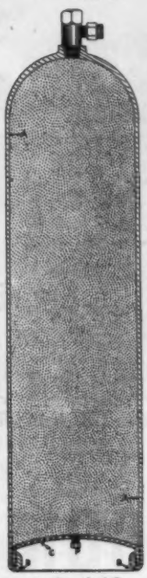

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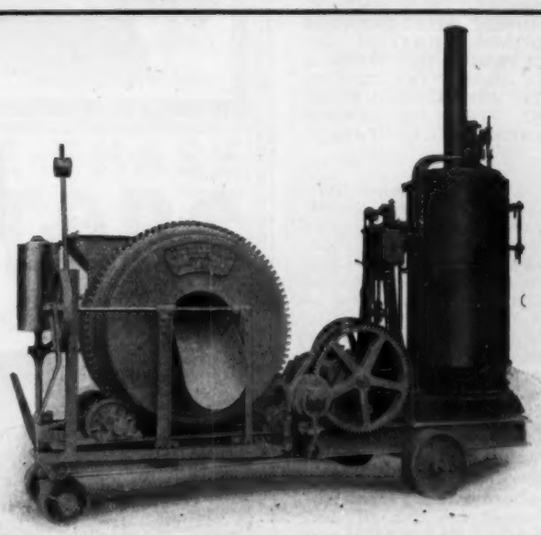

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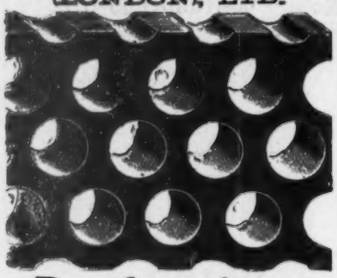

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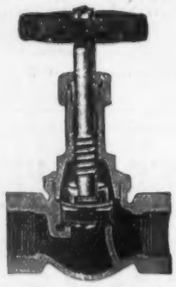

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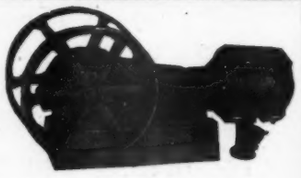

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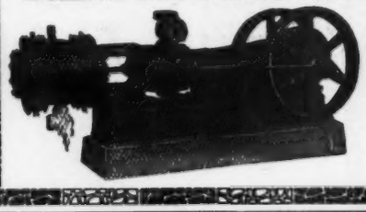

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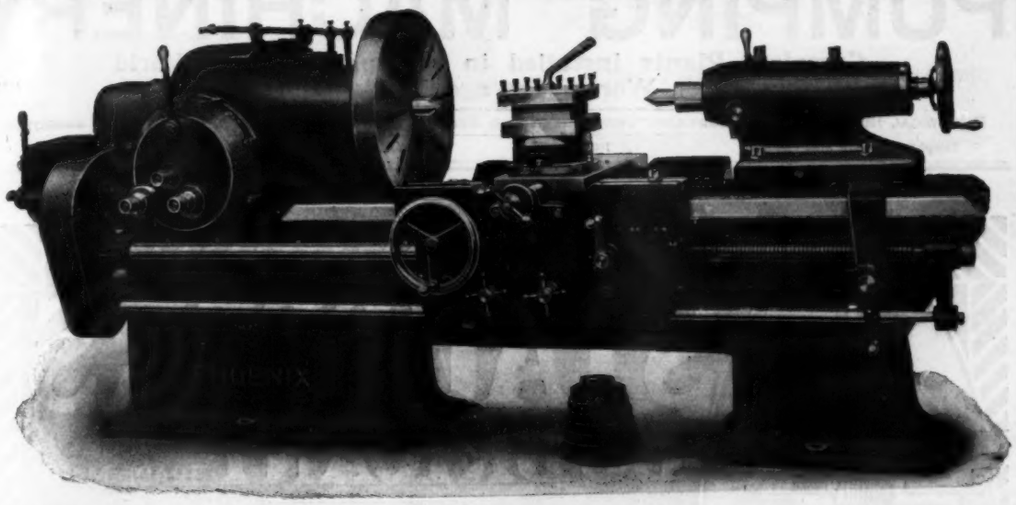

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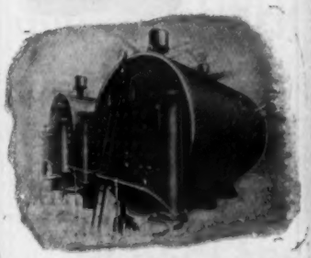

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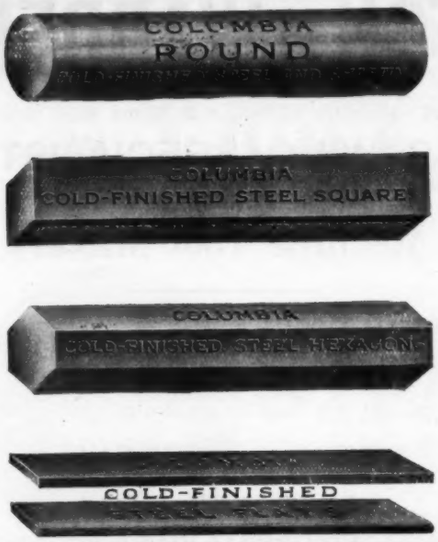

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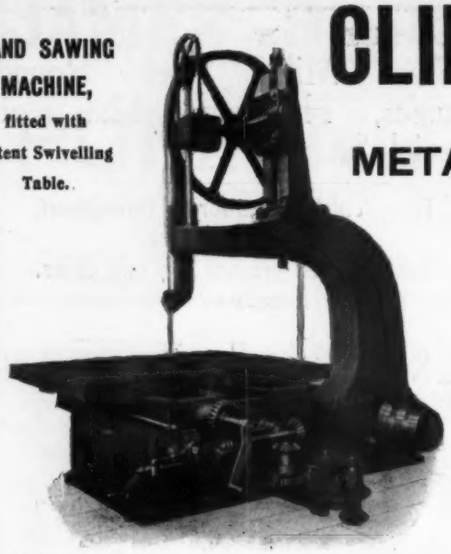

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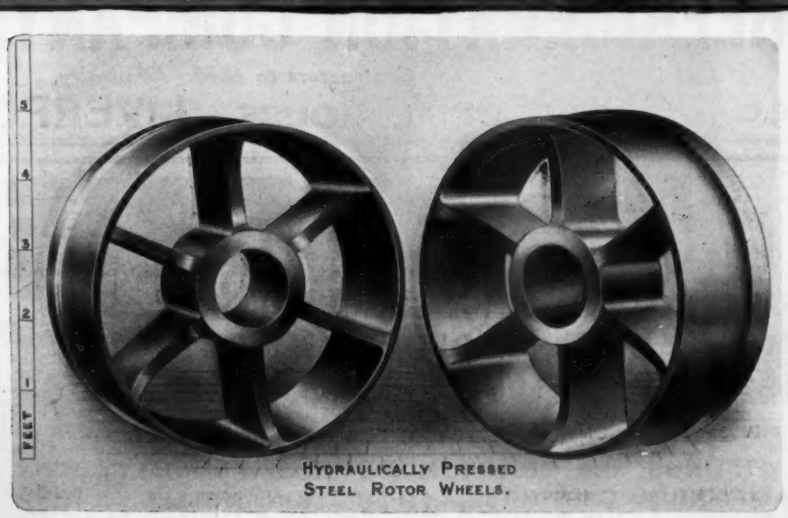

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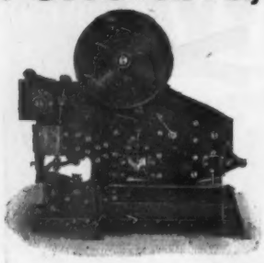
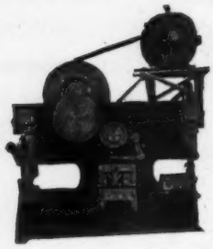
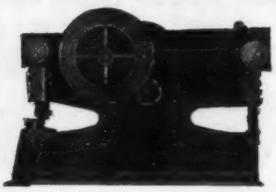

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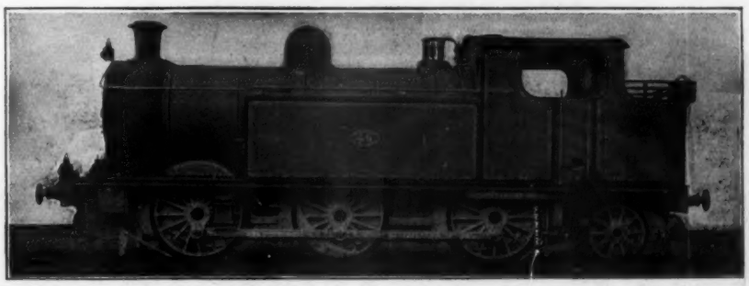

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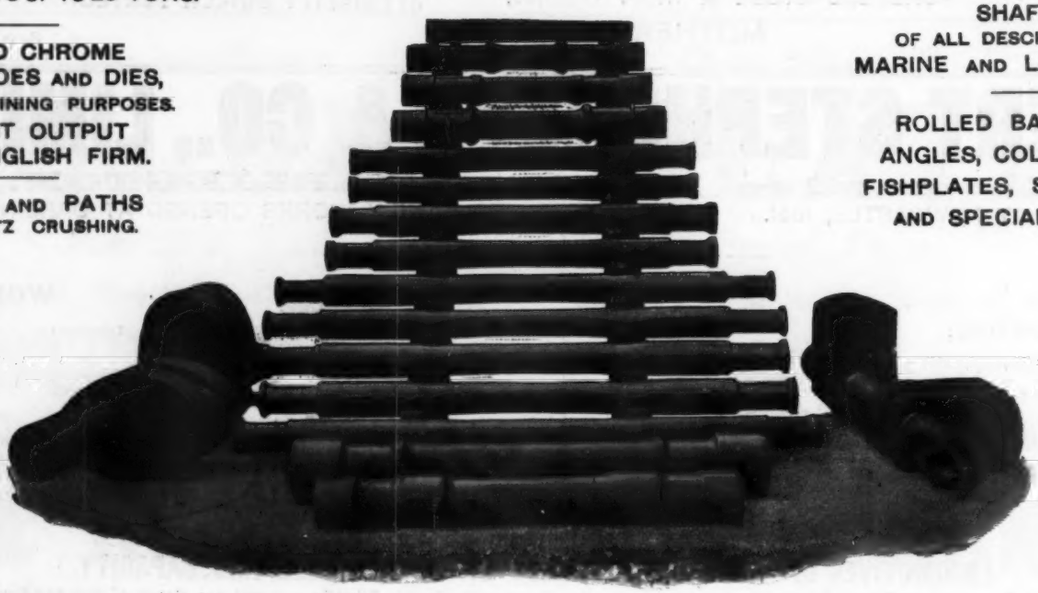

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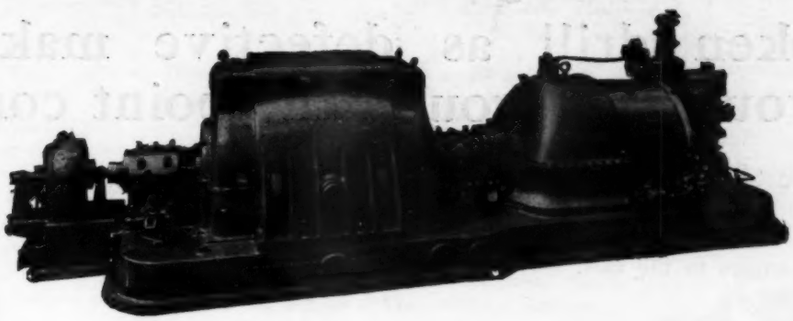

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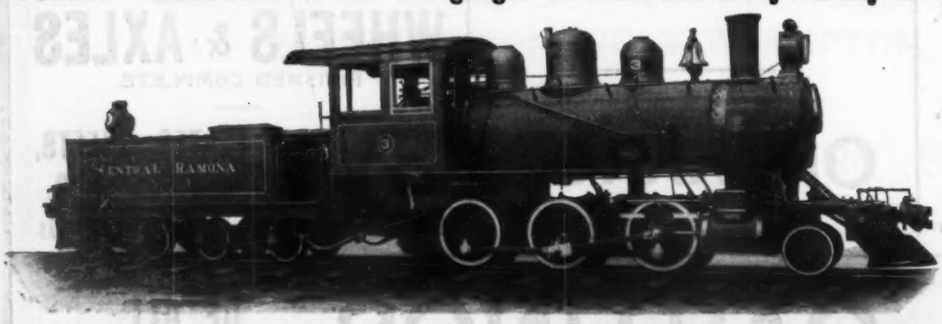

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The STANDARDISATION of CUTTING TOOLS.

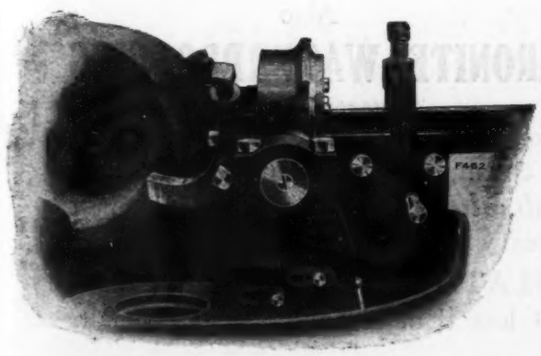
By A. H. C.

During the past two or three decades the word Standardisation has stepped out of our dictionaries and has assumed a practical form that is thoroughly understood by the few, partly understood by others, but only indifferently understood by the many. The period referred to has seen many and wonderful changes in our machine shops, and we hope we are not false prophets when we assert that the next decade will still see more marvellous changes.

Certain it is that one change will be that of more intense specialisation and consequent standardisation —first, in the objects of manufacture, followed quickly by the methods of production. But when all is said and done, there will remain this obvious fact, that cutting tools will still be required for our lathes, planers, shapers, slotters, turret and capstan lathes, boring mill, and any new specialised machines we consider necessary for our reorganised plants.

We must also face another fact in the near future and that is concerned with production. Production, in the new trade war rapidly developing at the present time, will have to be intensified. We shall have to obtain the maximum efficiency from every machine in the shop. The question of Cutting Tools is intimately bound up with the problem of intensified production, for unless we employ efficient tools, how can we expect to obtain efficiency from our machine tools?

Every machine must have available an adequate supply of the most efficient tools for each operation performed on it. Further, those tools must be manufactured on an efficient basis—that is, they must be cheaply made and easily maintained in good condition.



GRINDING A CRANKED ARMOUR-PLATE TOOL.

The first thing to do is to carefully consider the standardisation of all the tools in use in the shop. The number of varieties of tools should be restricted to the minimum consistent with good work. This simplifies and cheapens their manufacture. The standardisation of tools is not an easy matter when first tackled; each man has his own ideas on what is the best tool, so that the one entrusted with the work of standardisation should be a man of wide experience and great tact.

Next, the workman must be prevented from altering the tools served out to him, while full provision is made so that he need never be kept waiting for a tool longer than is necessary to obtain one from the stores.

A Tool Grindery is rapidly becoming of first-rate importance. It should be laid out to suit the needs of the shop or shops it is intended to serve. Bar racks will be required at one end for storing the high-speed steel bars from which the tools will be made. Then there will be some hack sawing machines for cutting off, and one or more blacksmiths' hearths for any forging required.

GRINDING A TOOL WITH HOLLOW CURVED TOP FACE.

The Grindery will be completed by the installation of Lumsden Grinders, Oscillators for roughing to shape before hardening, and Plain Grinders for finishing after hardening. There is no system of Toolmaking in existence at the present time so simple, so easy and so cheap as the Lumsden system.

The chief features of the Lumsden Oscillators are the universally adjustable toolholder and the power oscillation of the grinding wheel. Grinding is so easy that it is cheaper to remove a large amount of metal —even high-speed steel—in forming to shape, than it is to forge it in order to save metal. This fact has been proved over and over again in many large works in the British Isles and elsewhere.

So, on all tools smaller than, say 1½ in. square section, it pays to eliminate forging almost entirely, the exceptions being those few tools which must be bent or drawn down to a blade, such as parting tools.

Another advantage obtained by adopting the Lumsden system is the fact that it is possible to grind a hollow curved face on the top of a tool. This operation, prior to the Lumsden device, was a difficult one to do, and could only be done by hand. The Lumsden device renders it well within the capacity of an inexperienced operator to duplicate tools with a hollow curved face.

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Lumsden Machines have been and are being used in very large numbers for the manufacture of spade cutters. Blanks are mounted on an arbor in the toolholder and rotated with their edges presented to the wheel under the control of a hardened former in contact with a guide plate. By this method they can be roughed to shape in a fraction of the time taken by any other method.

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No. 3 Oscillator for large armour plate and similar tools up to 6 in. by 3 in. section.

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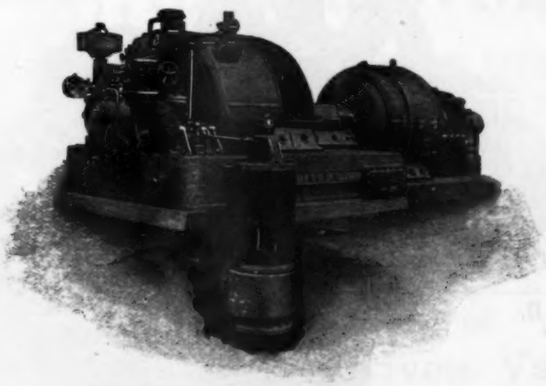

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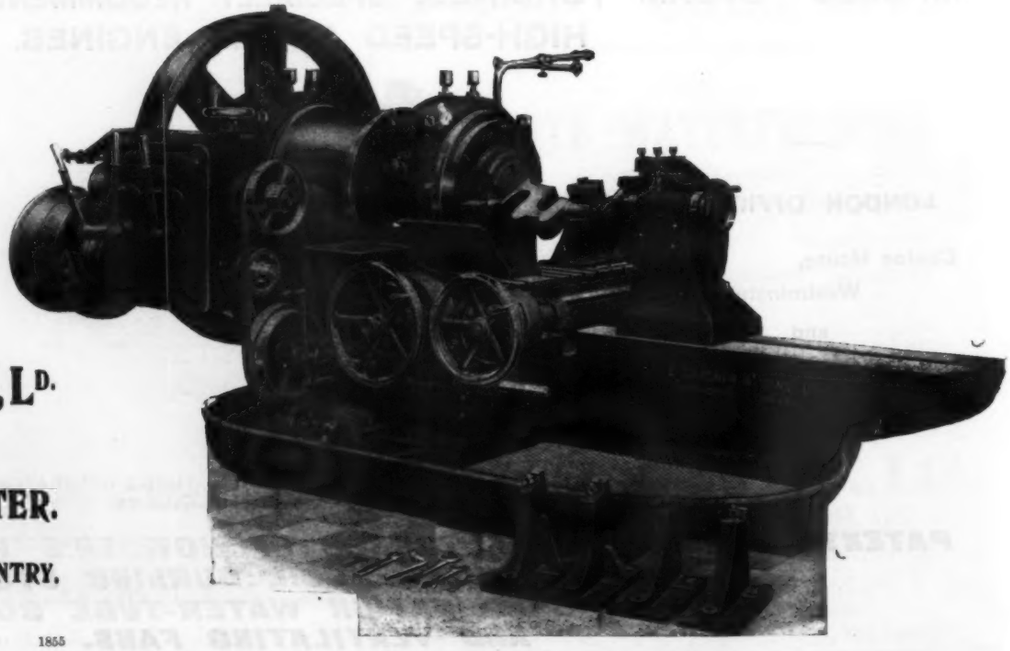

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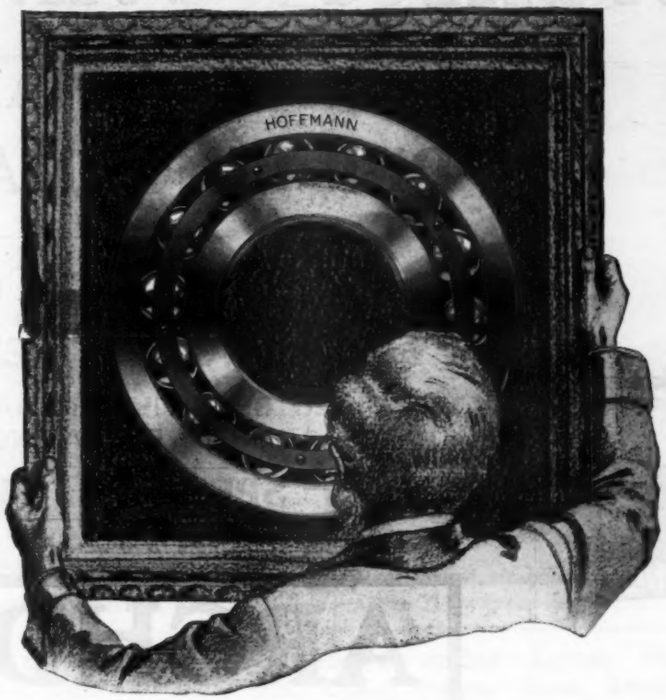

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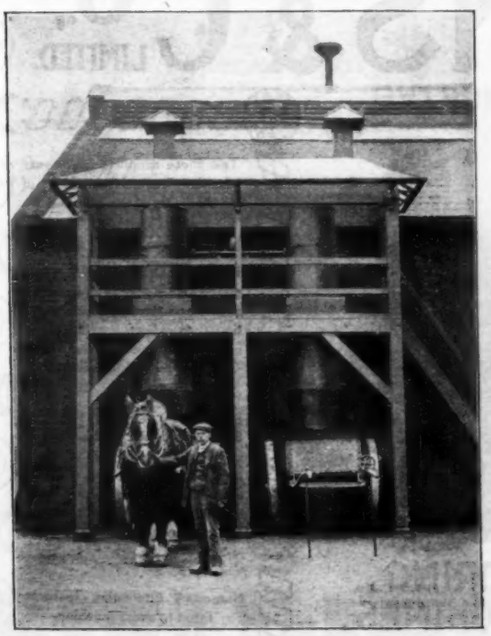

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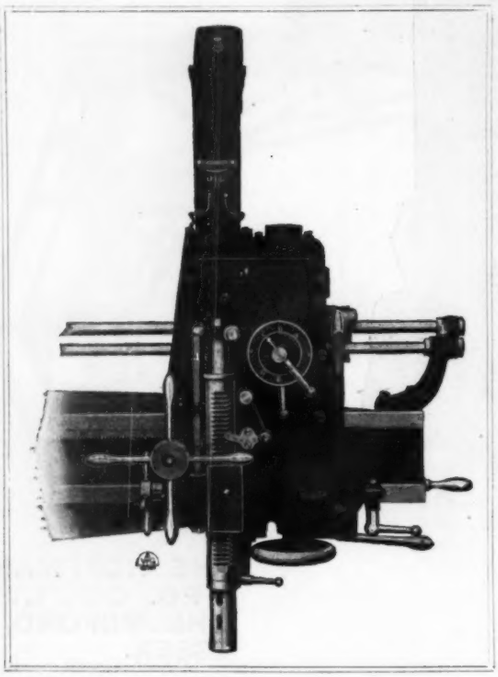

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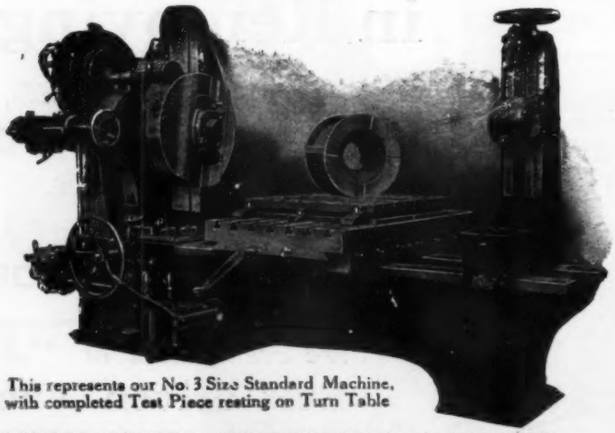

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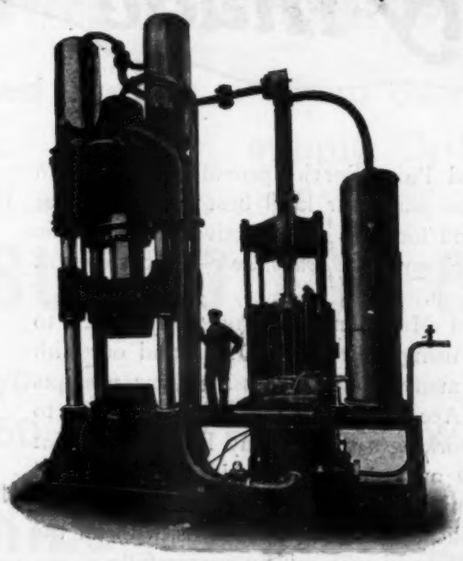

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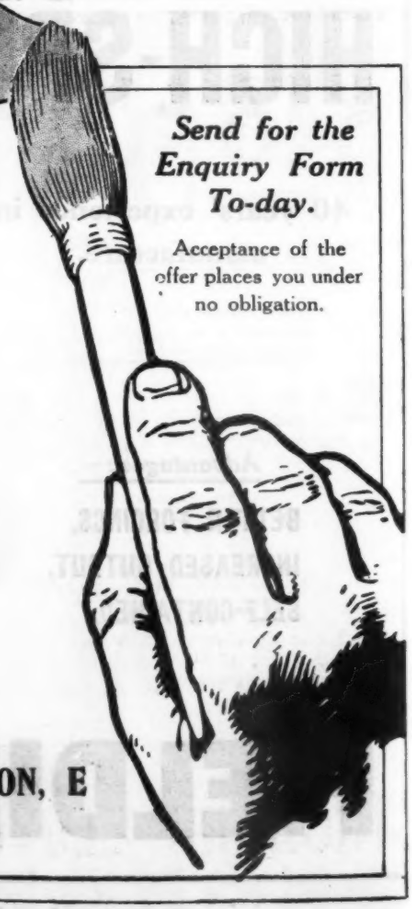

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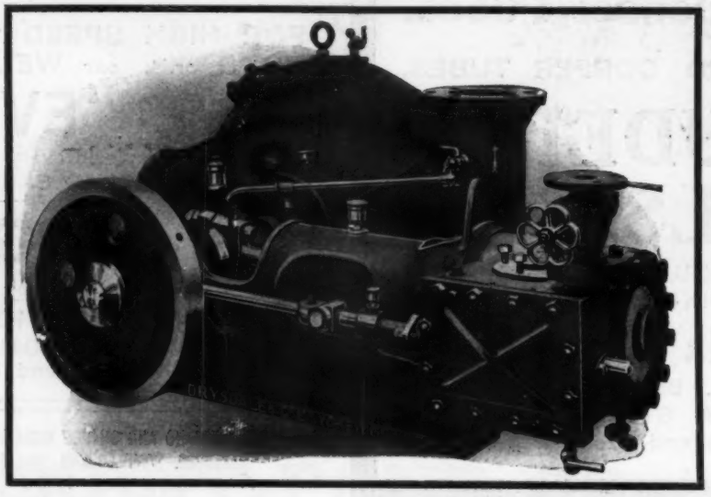

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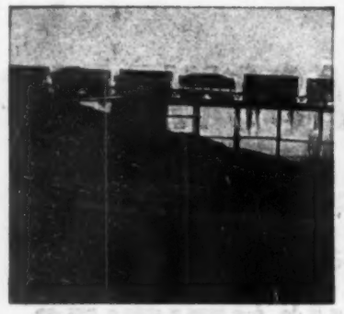

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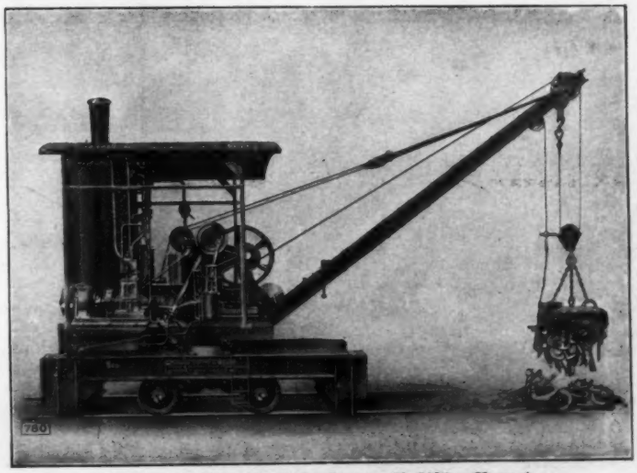

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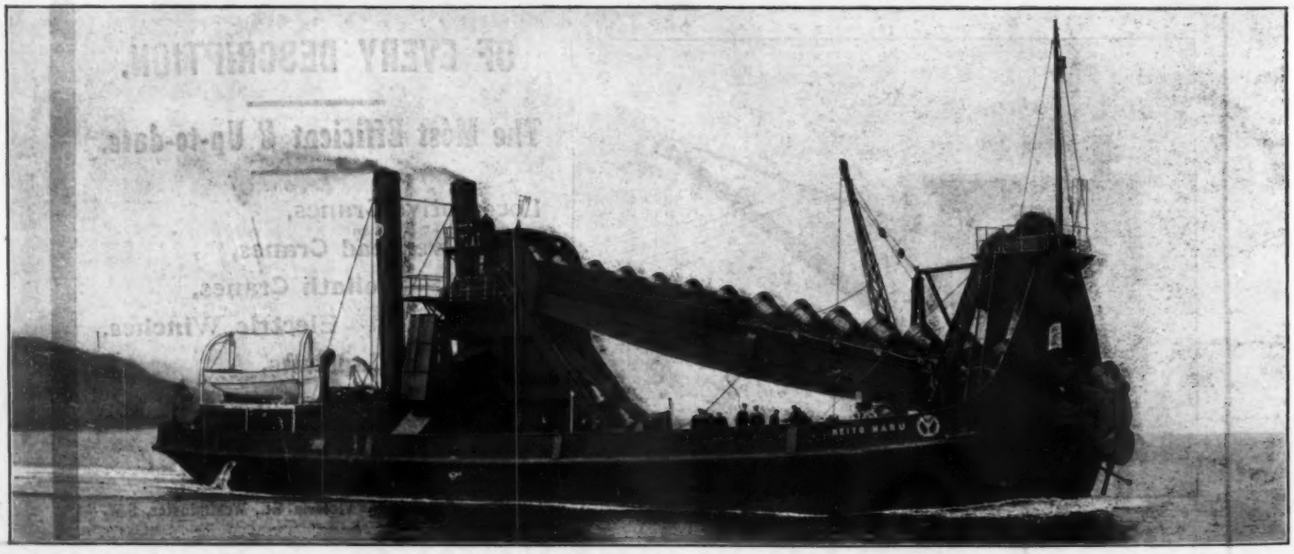

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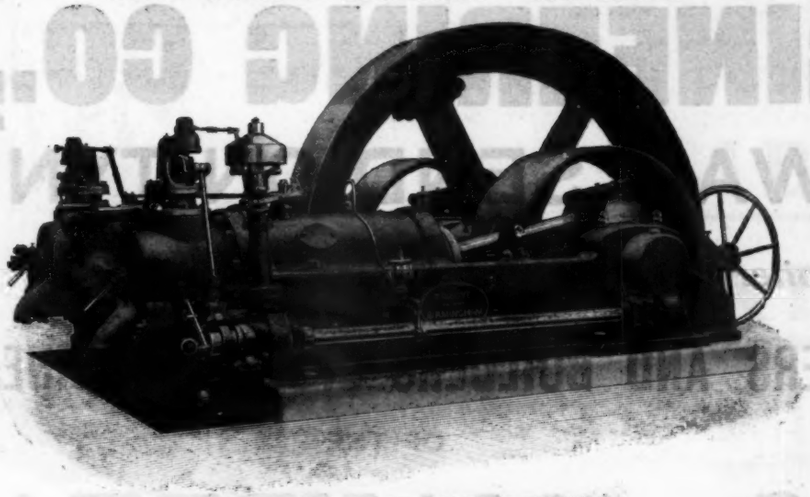

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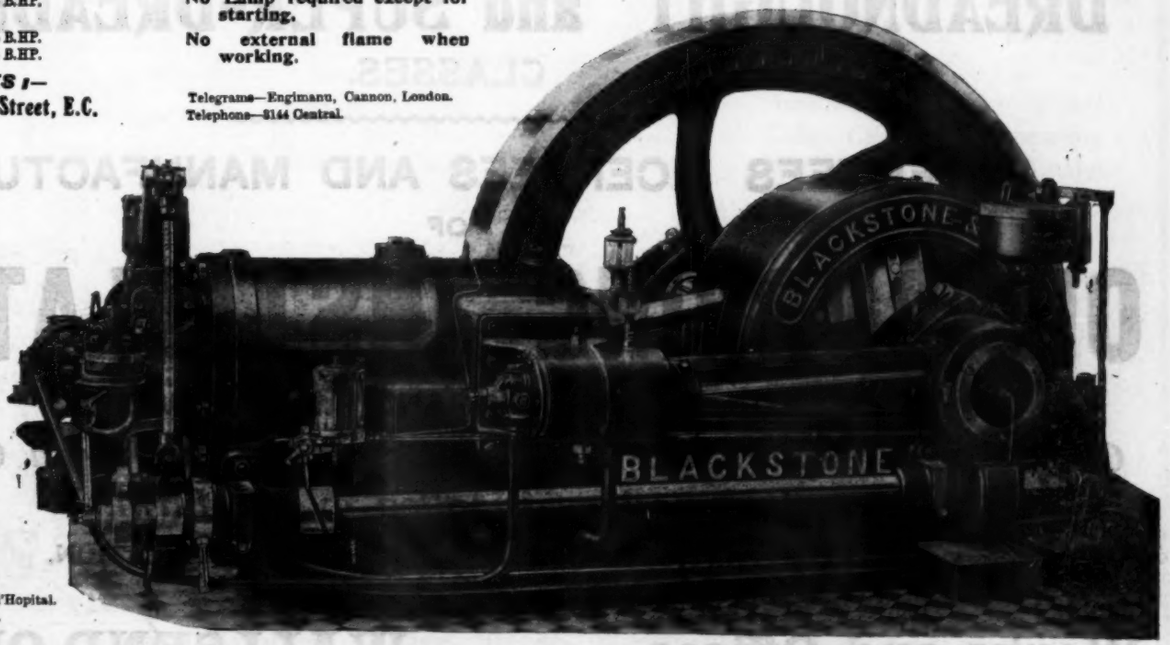

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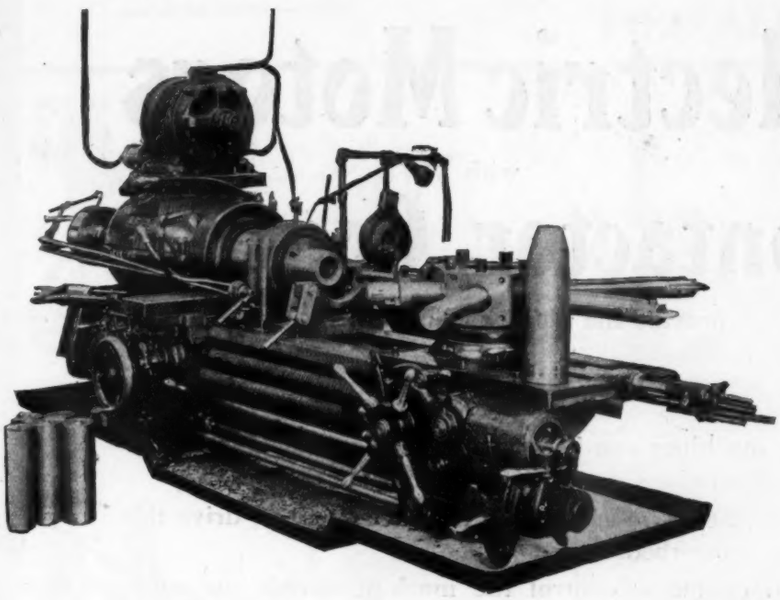

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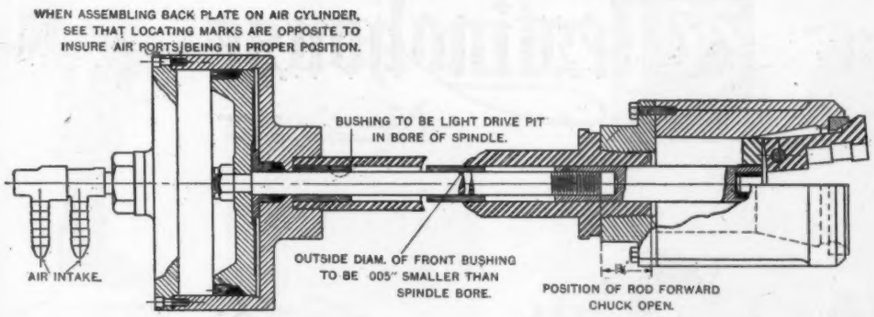
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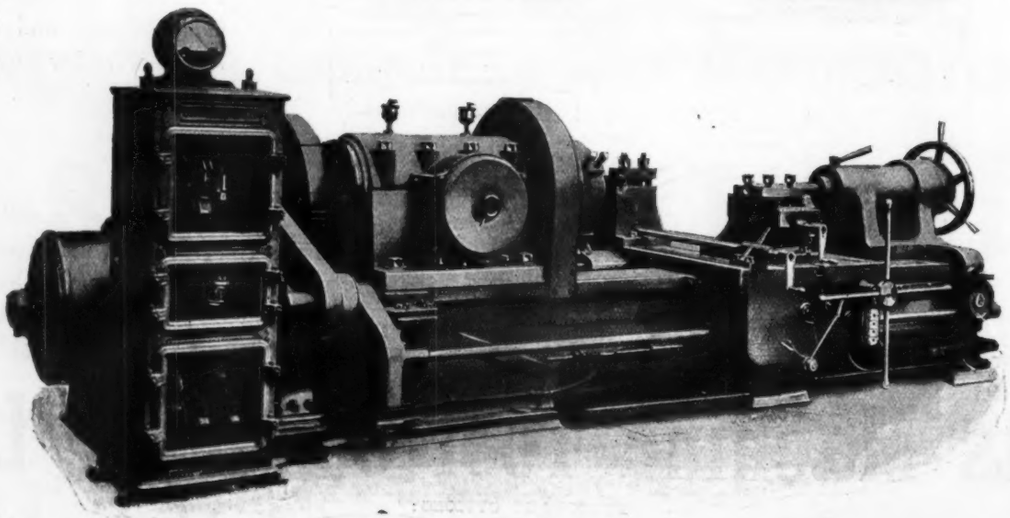

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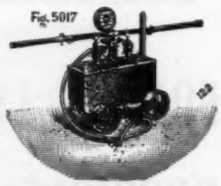

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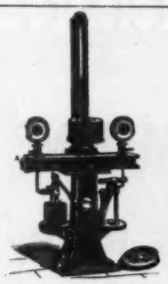
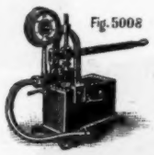


Fig. 5040.—BAILEY'S PATENT PRESSURE and VACUUM GAUGE TESTER.

Fig. 5033.—HYDRAULIC TEST PRESS. To test any size of pipe up to 18in. bore and 3ft. in length. Suitable for any kind of earthenware pipes.

Fig. 5041.—DEADWEIGHT PRESSURE GAUGE TESTER.
To 200 and 300 lb.
Useful to all large users of gauges.

Fig. 5112.—TWIN PLUNGER PRESSURE PUMP.
For Pressures to 2 Tons.



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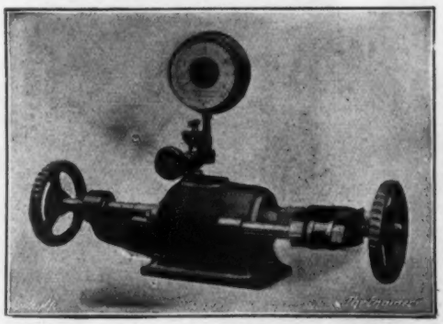

Fig. 5068.—STER-HYDRAULIC CRUSHING TESTER.
This Machine is used for testing the crushing strain of cement, concrete, stone and bricks.

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(Table pattern).
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Fig. 5120.—"THURSTON'S Patent RECORDING OIL TESTER.
Also for Testing Anti-Friction Metal and Bearings.

Fig. 5106.—PRESSURE and VACUUM GAUGE TESTER.
Fig. 5105.—Ditto, without Cabinet.

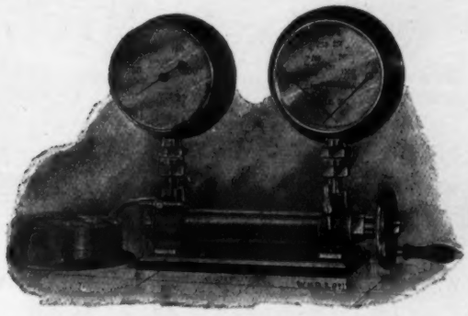
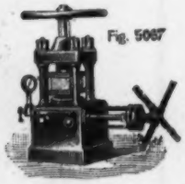


Fig. 5107.—PORTABLE GAUGE TESTER. For pressure and vacuum.



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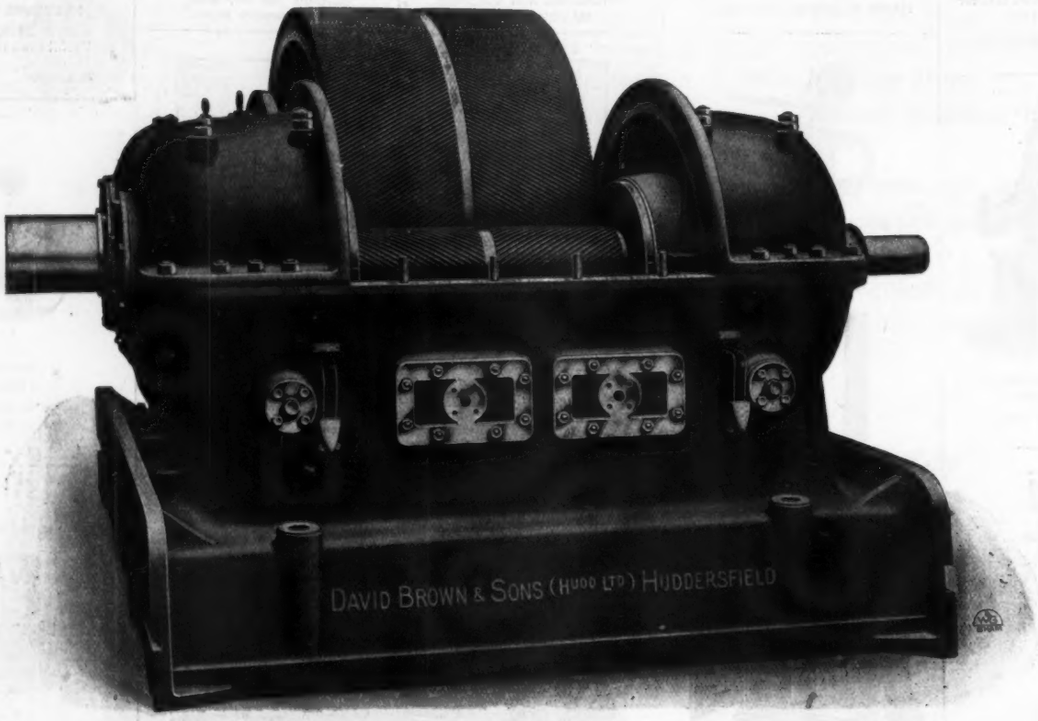

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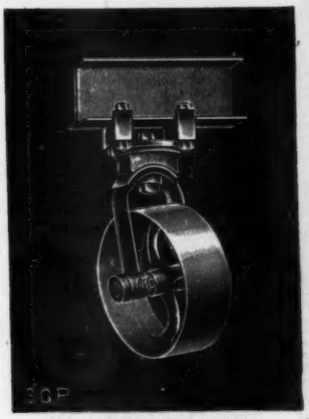

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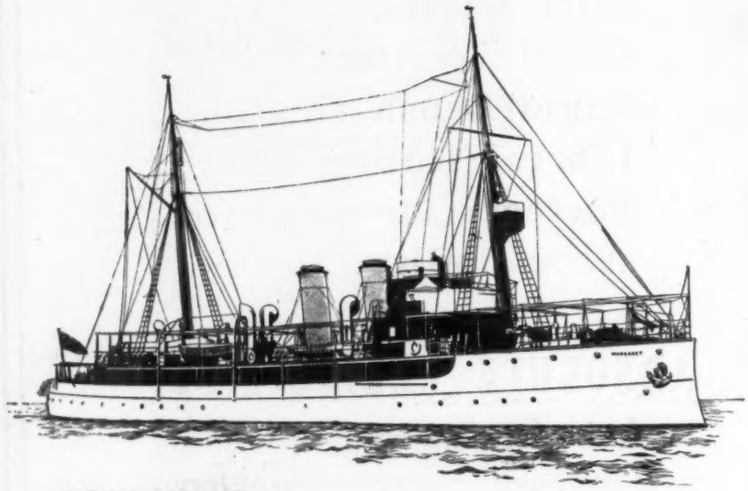

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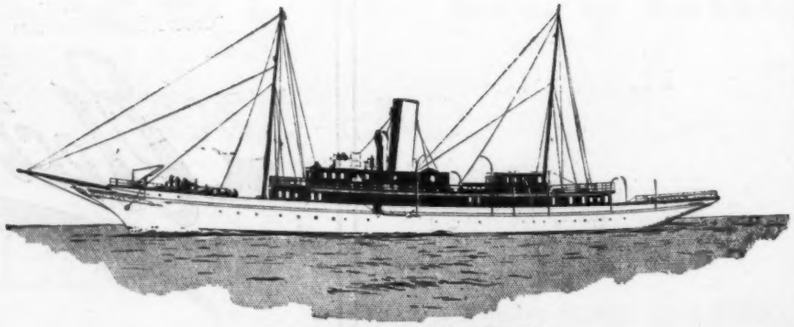

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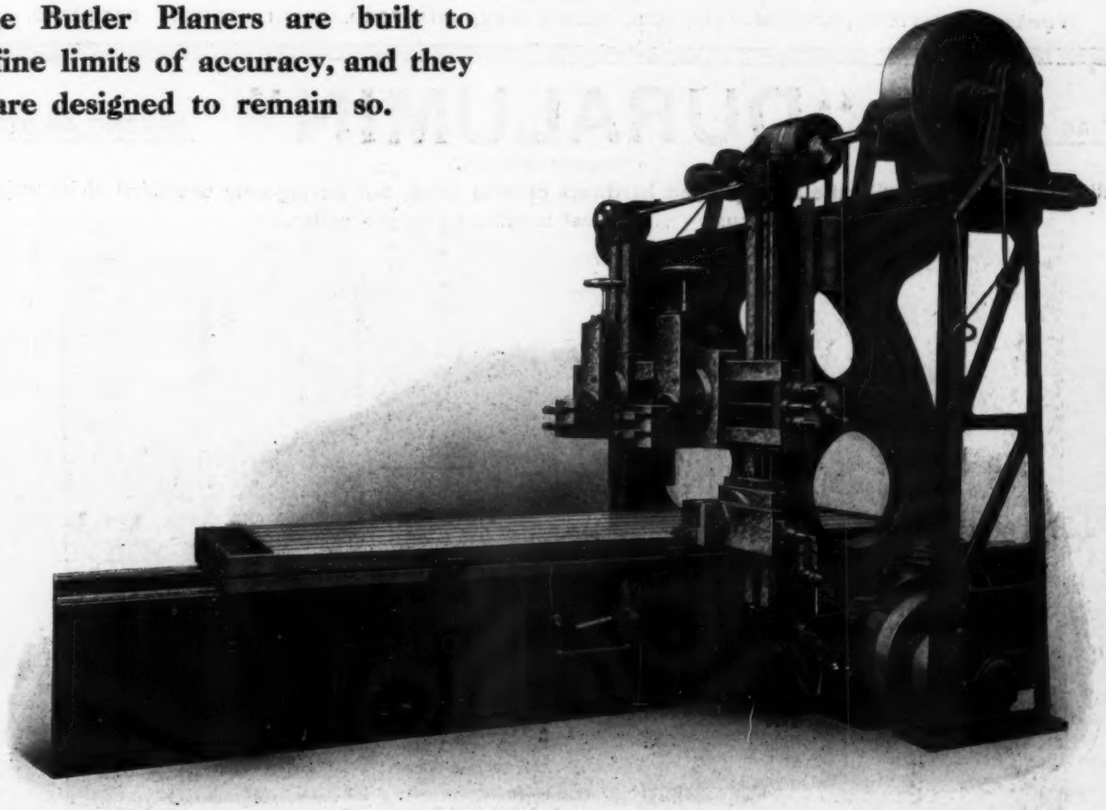

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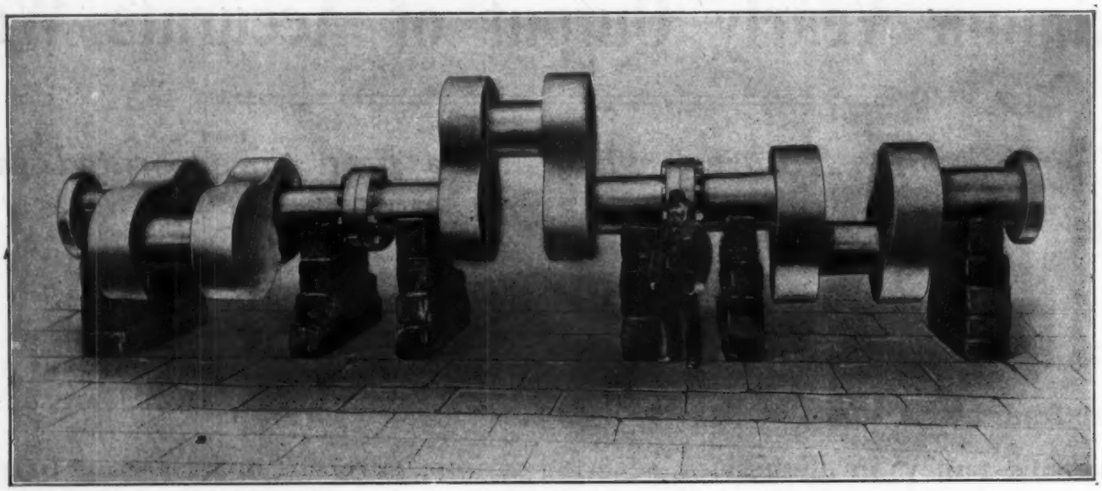

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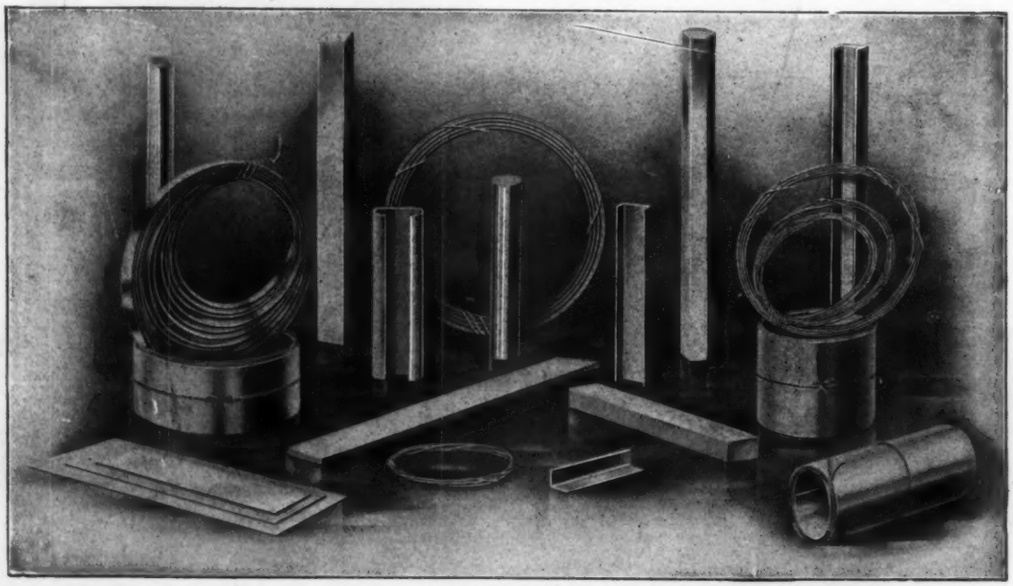

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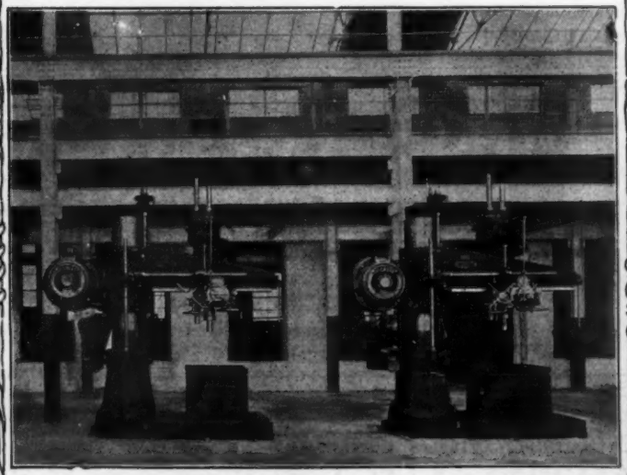

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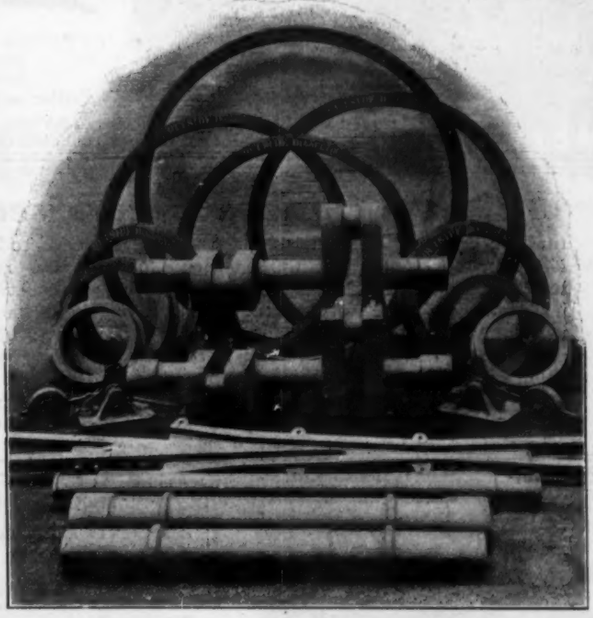

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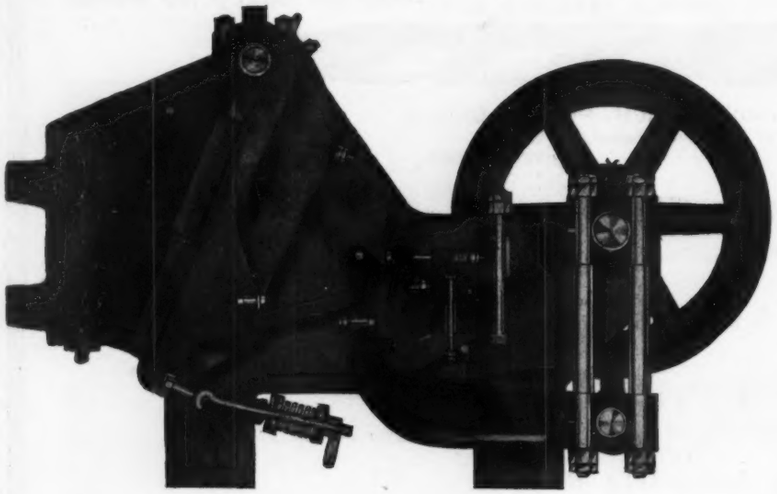

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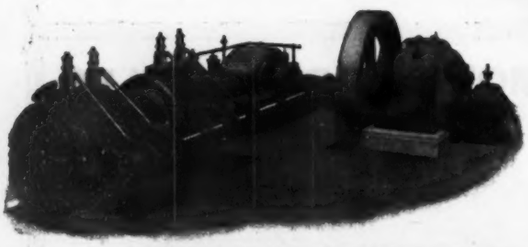

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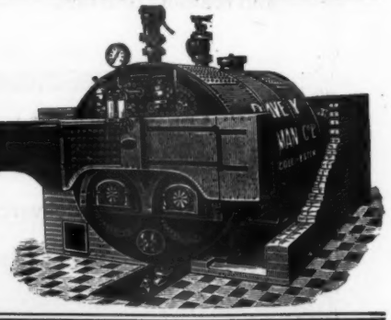

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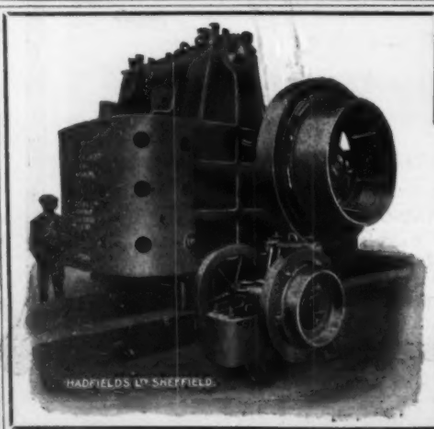

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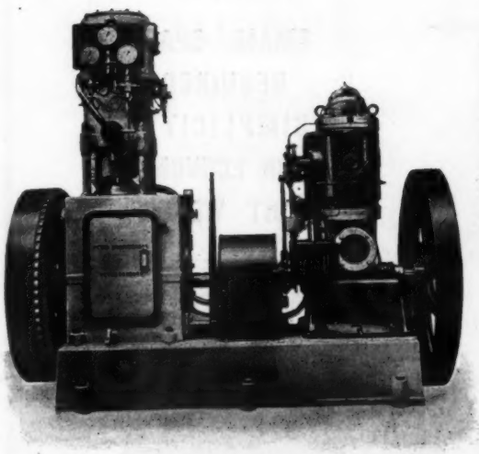

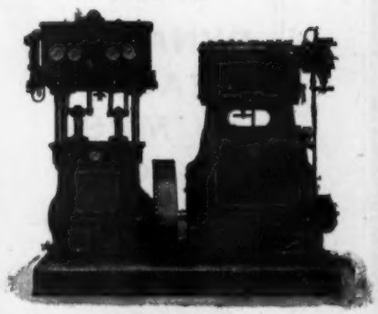

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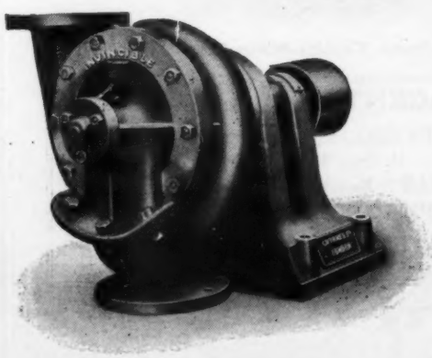

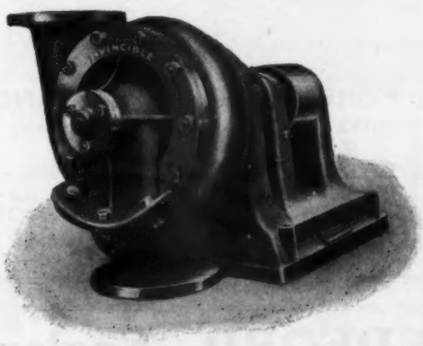

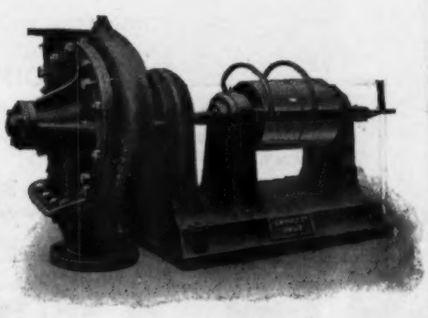

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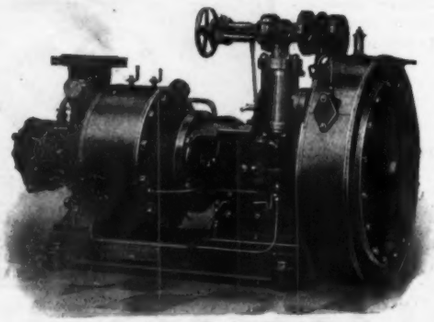

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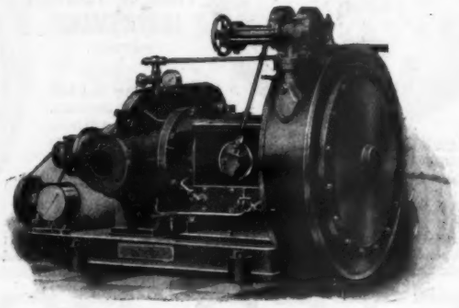

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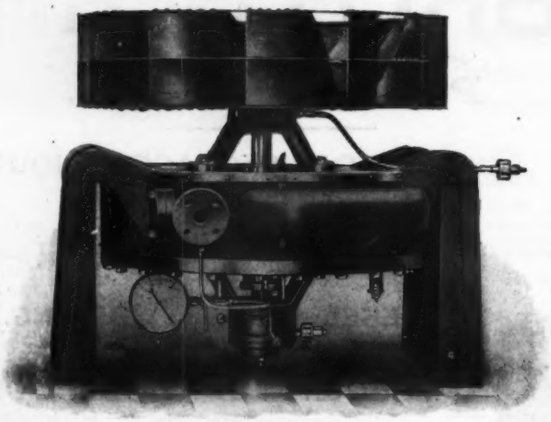

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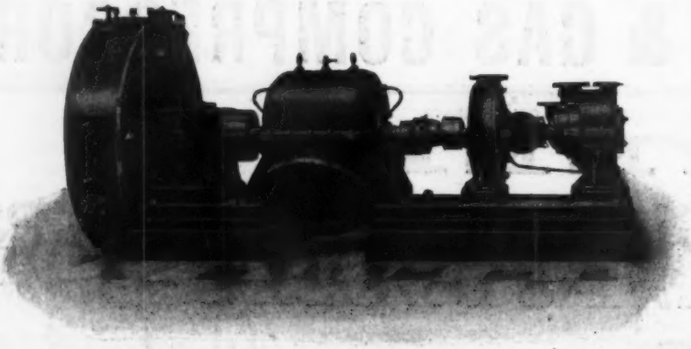

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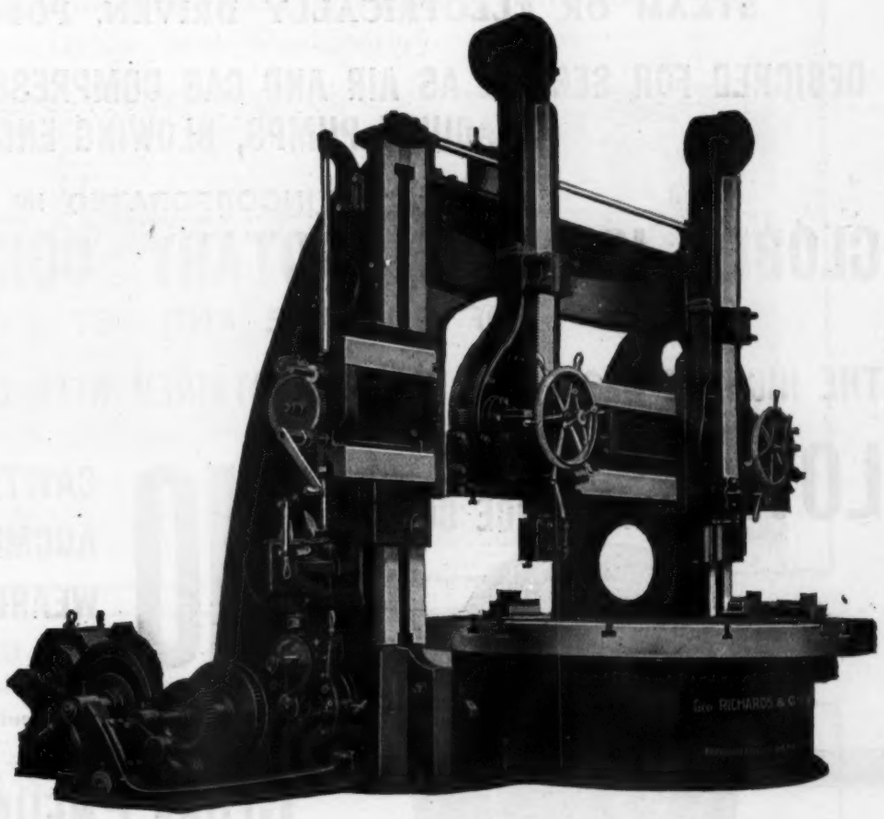

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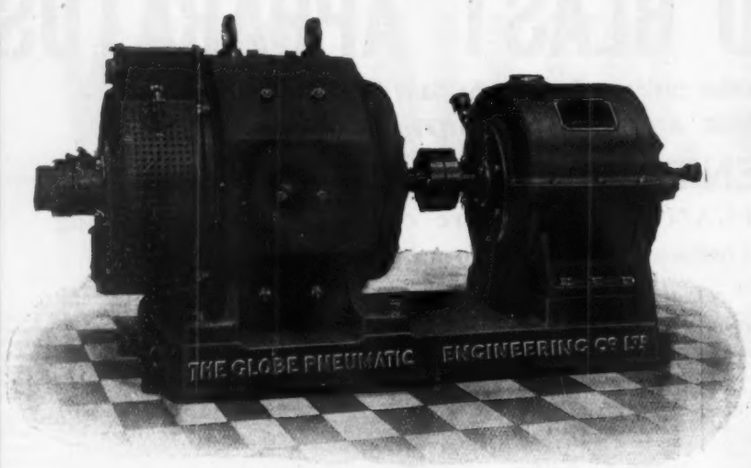

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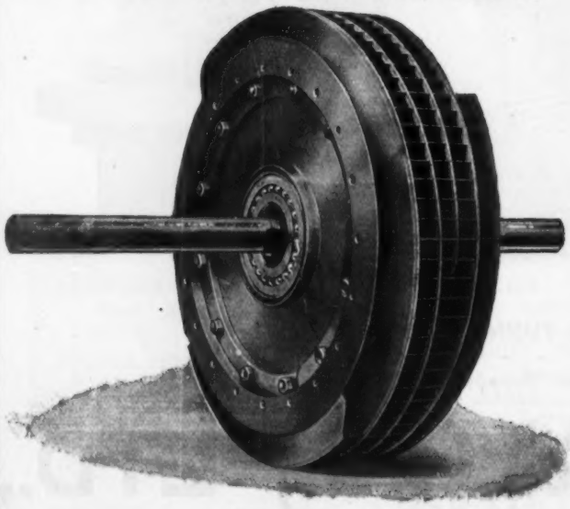

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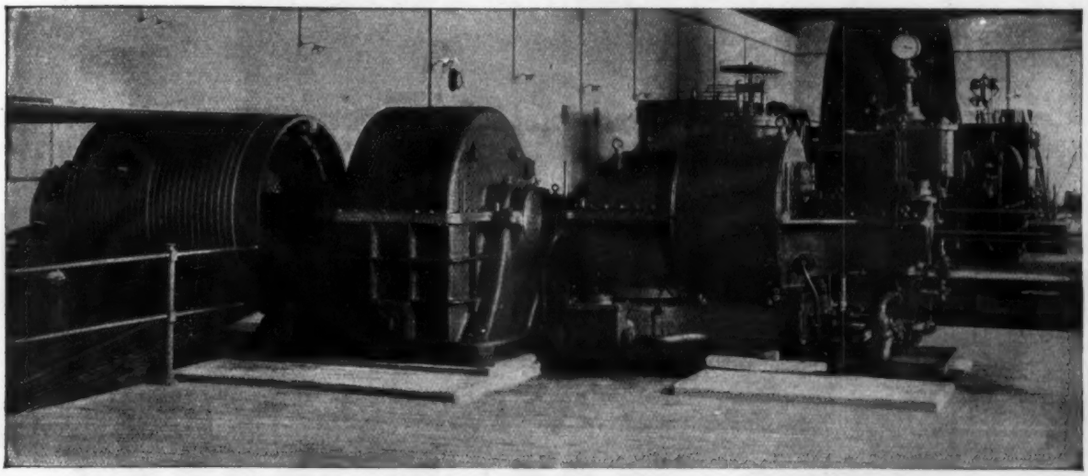

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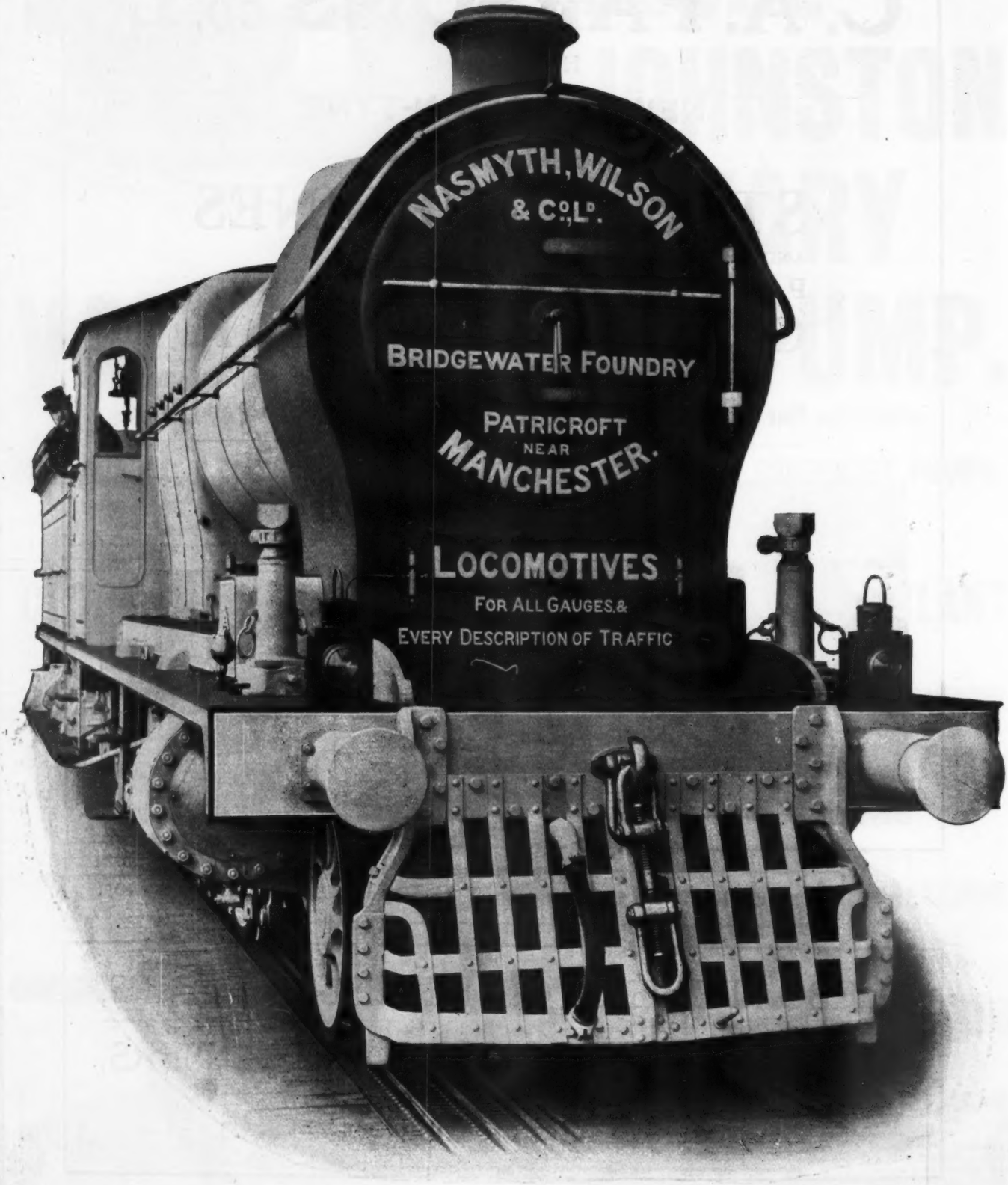
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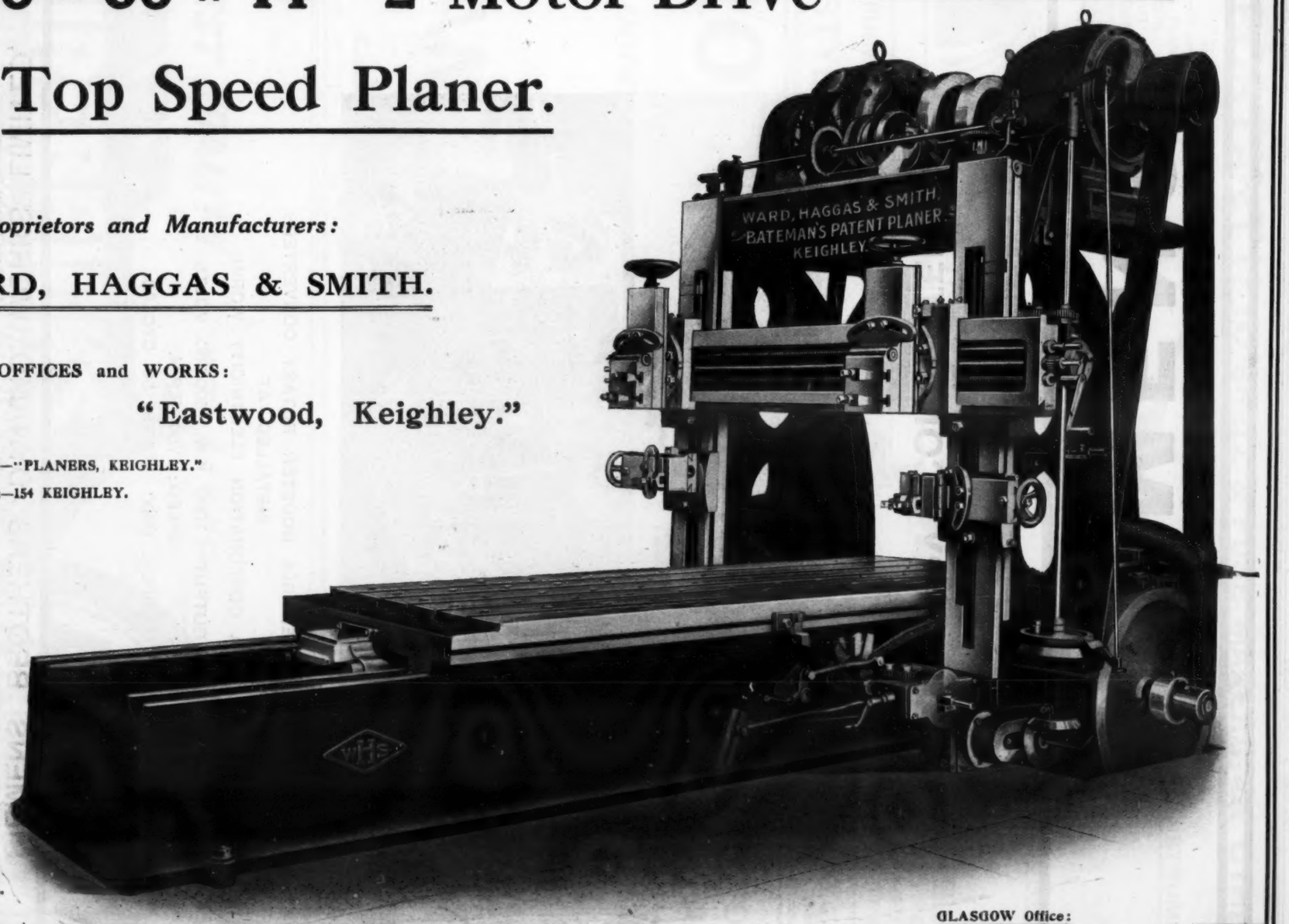

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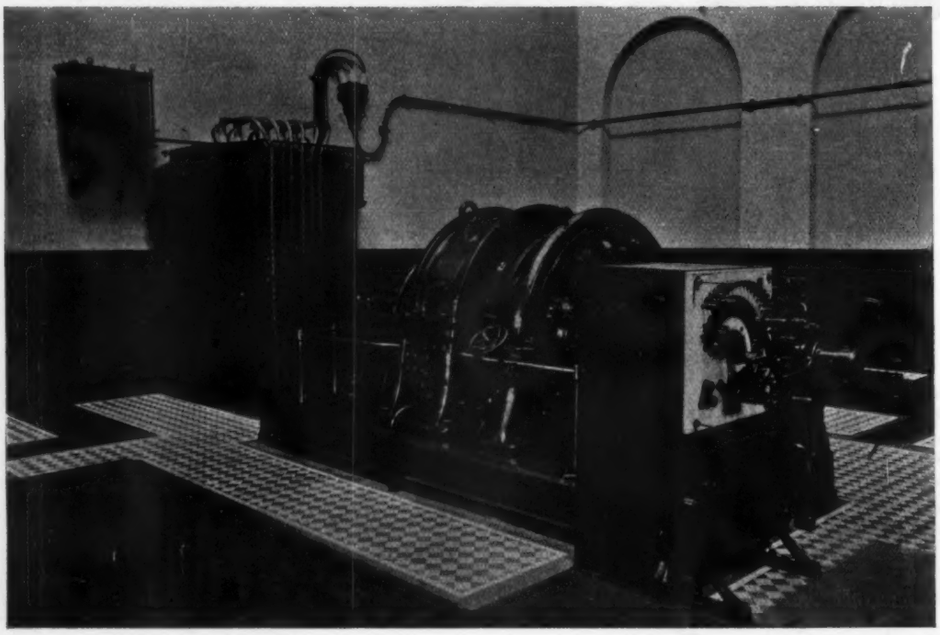

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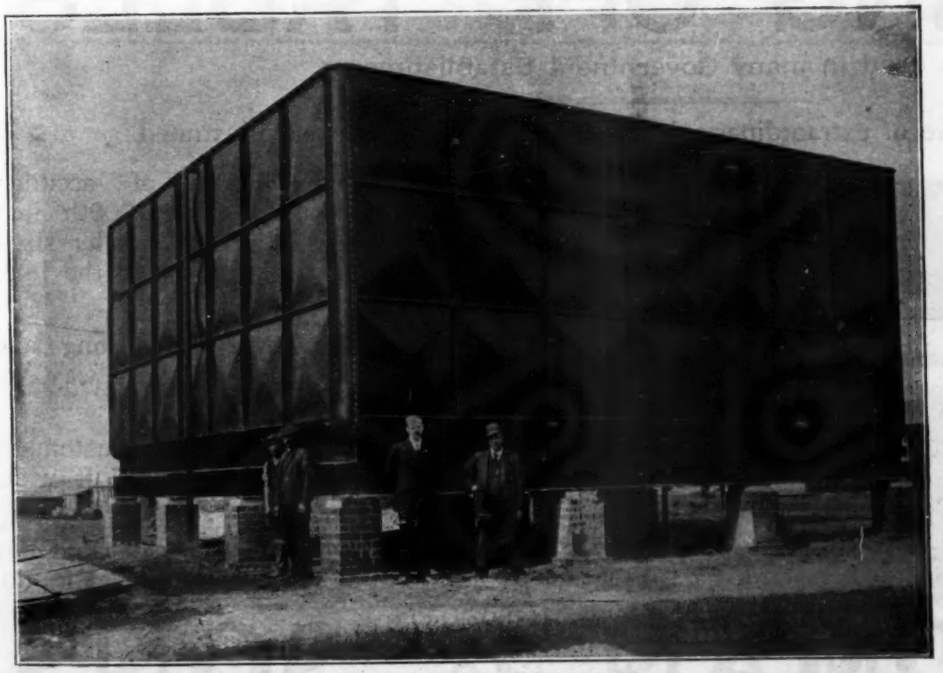

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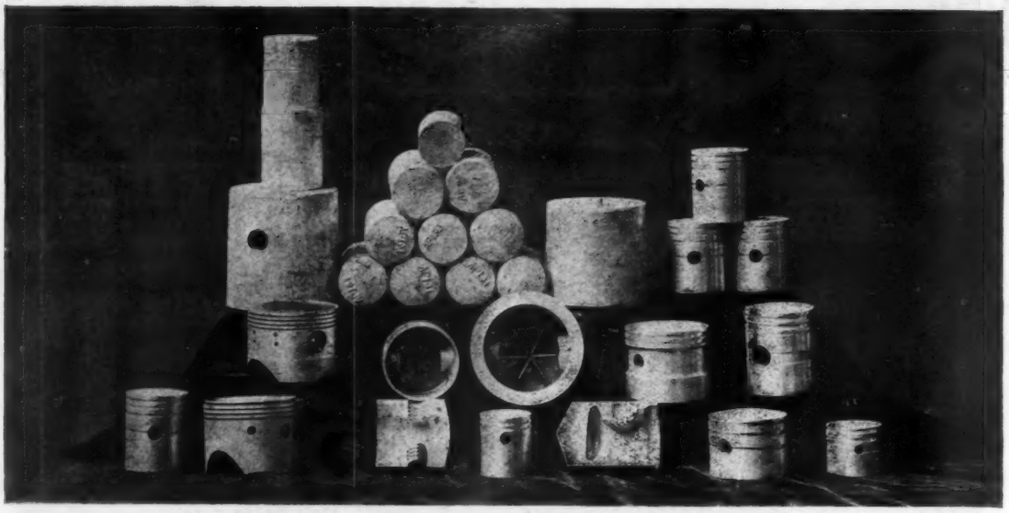

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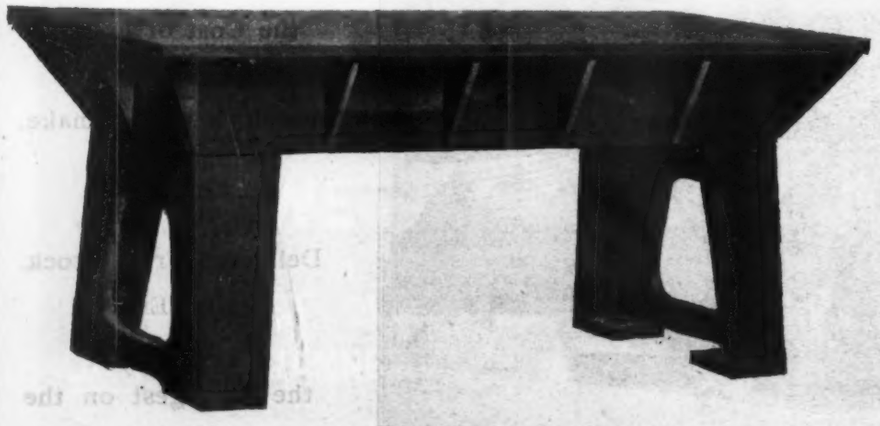

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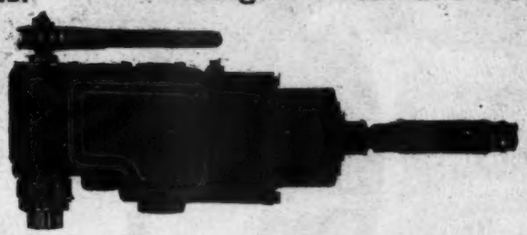

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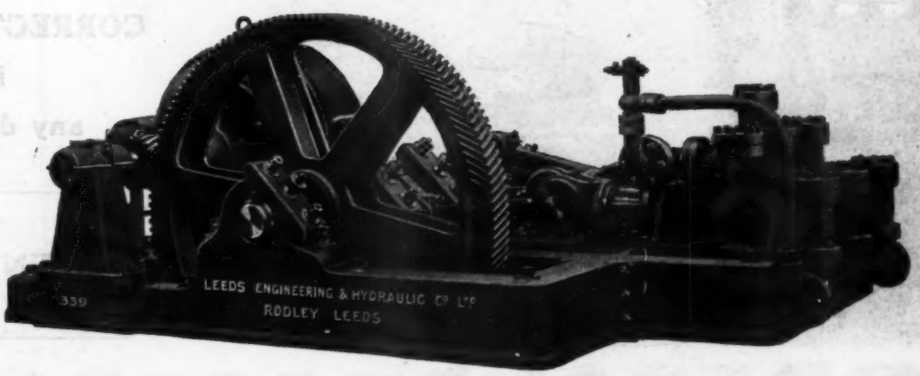

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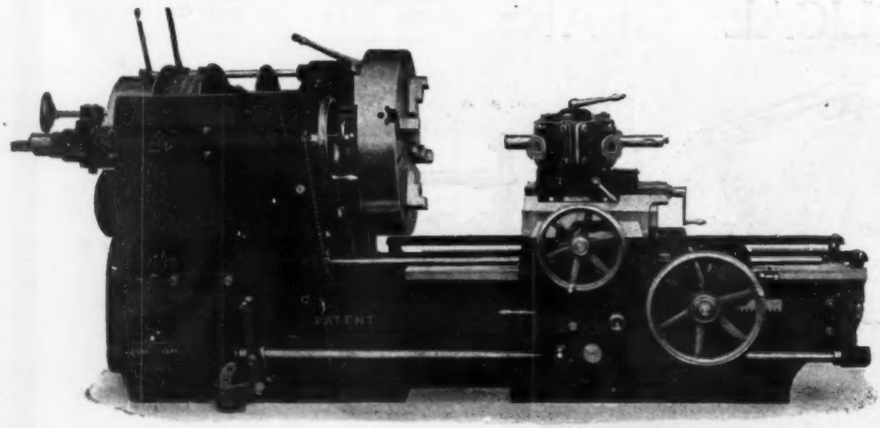

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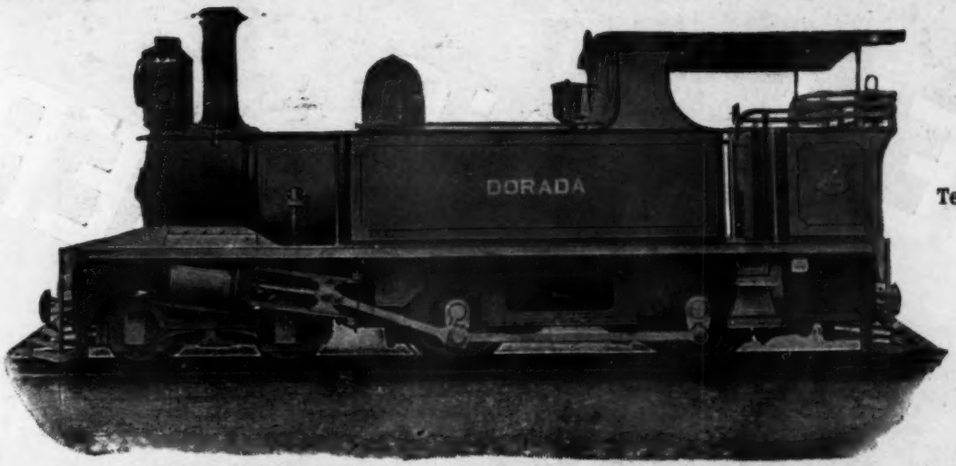

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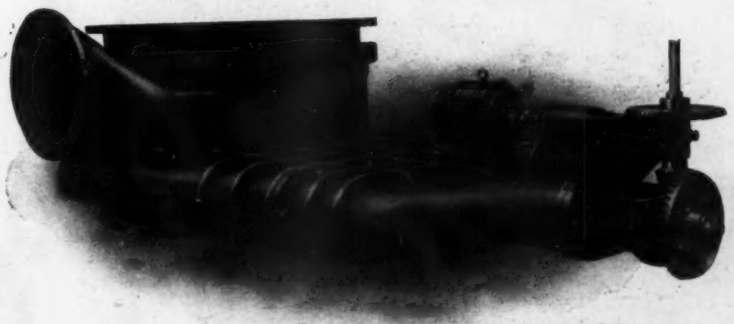

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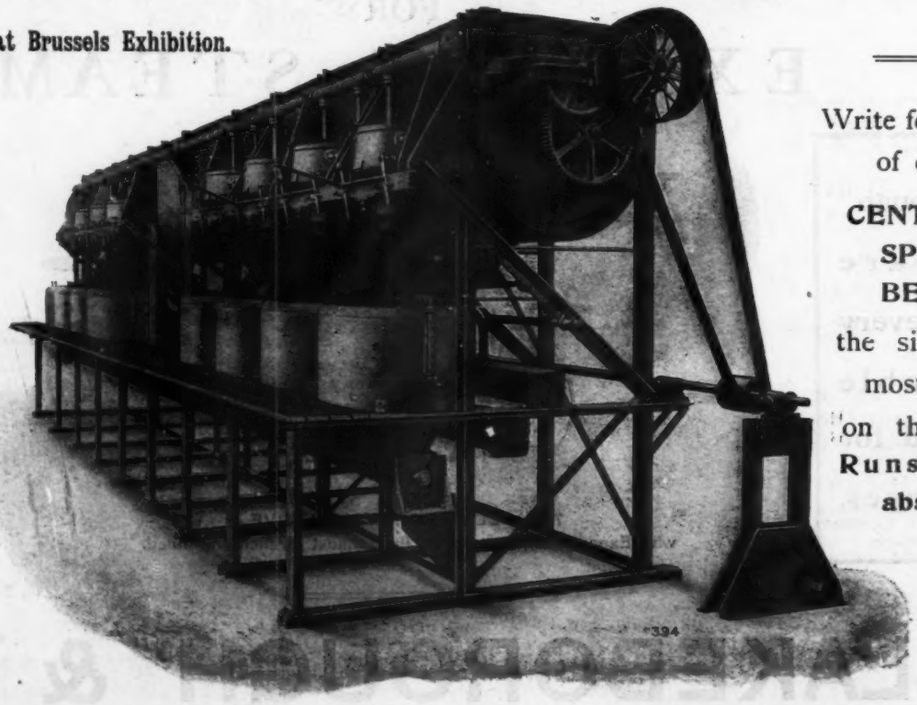

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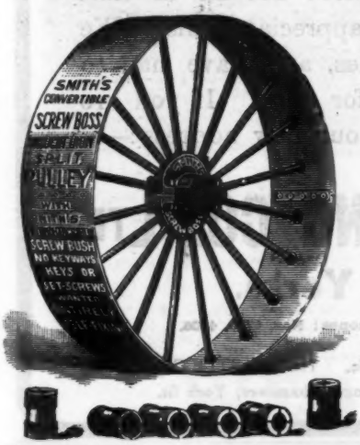

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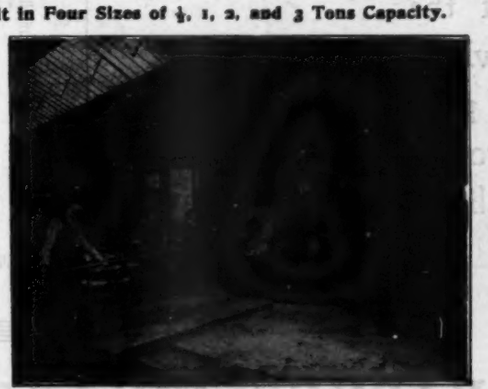

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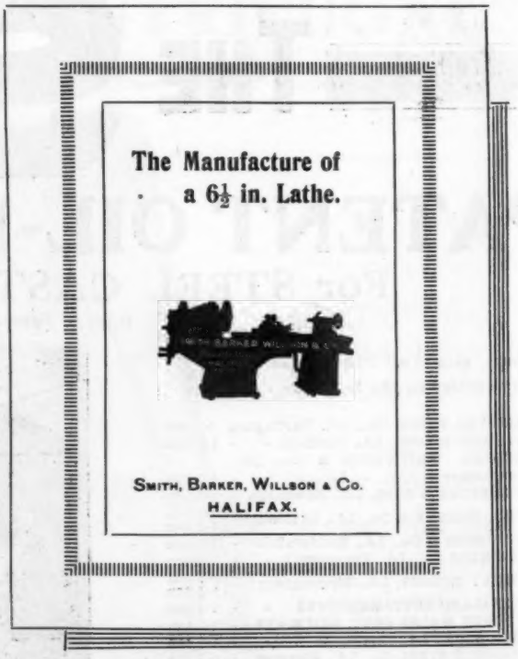

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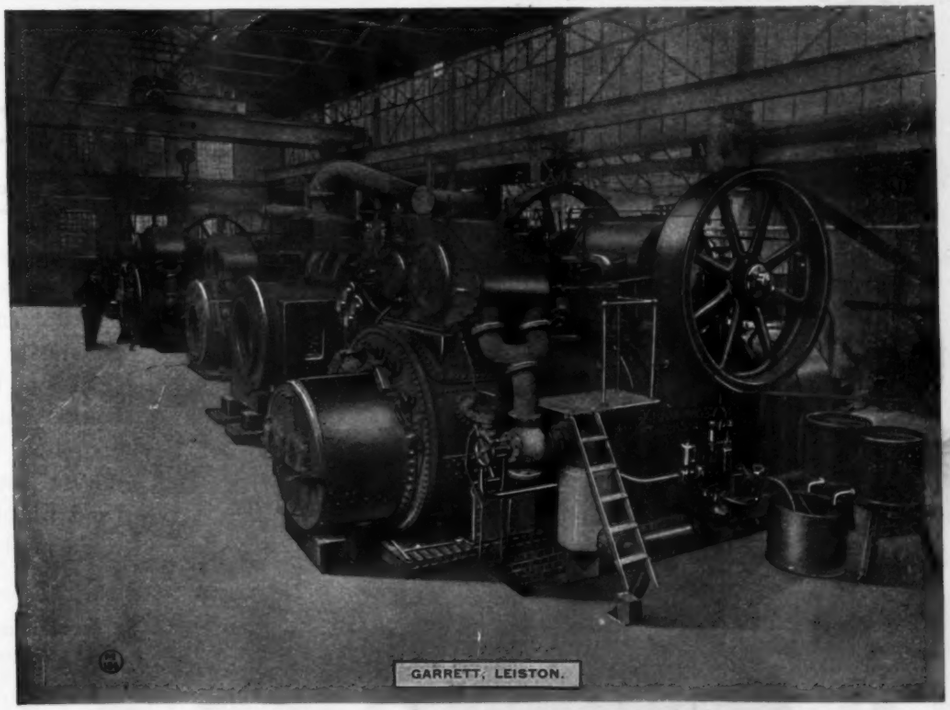

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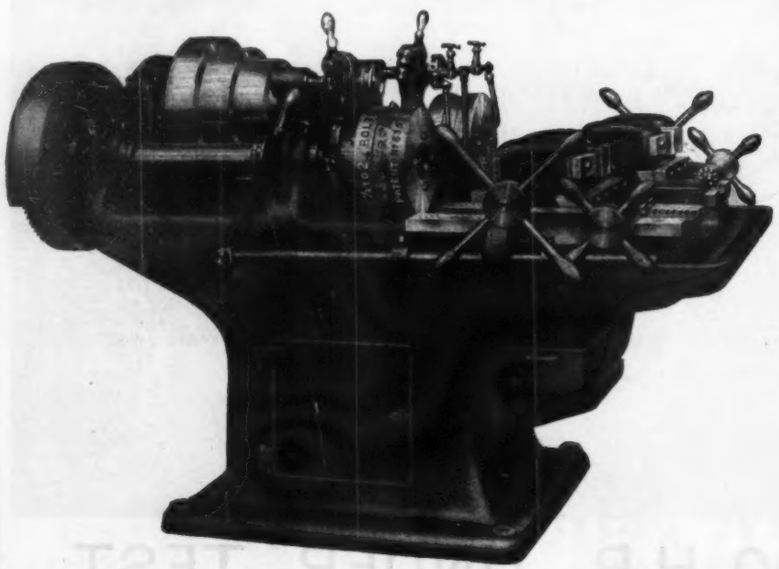

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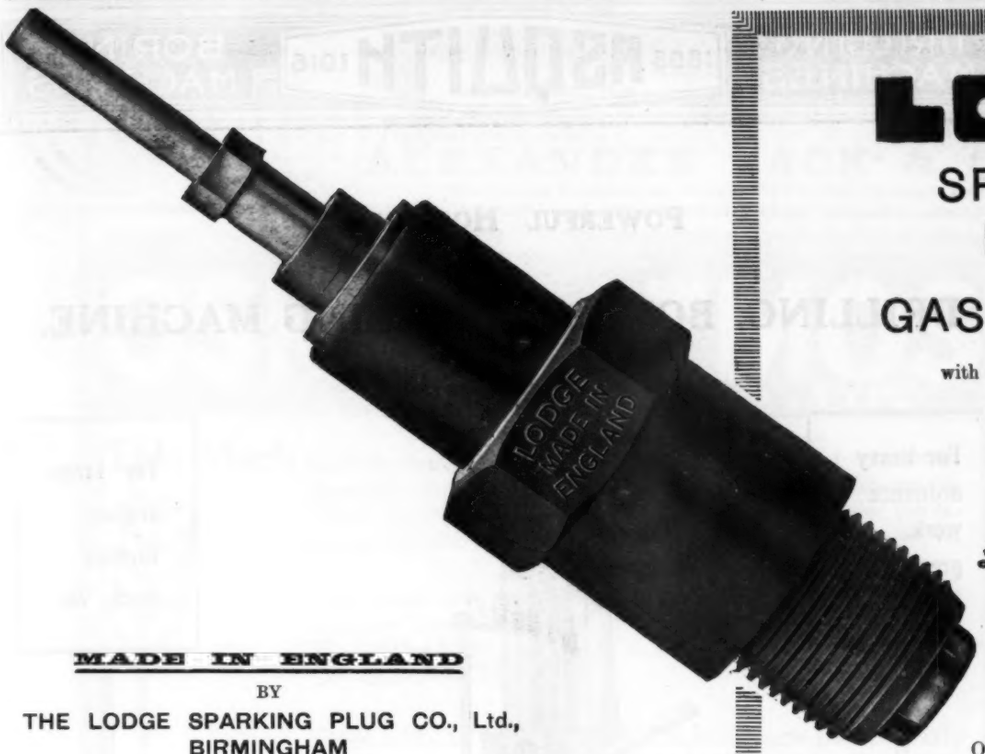

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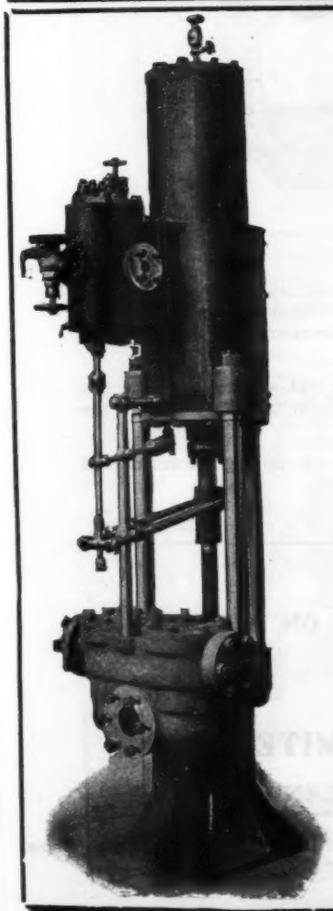

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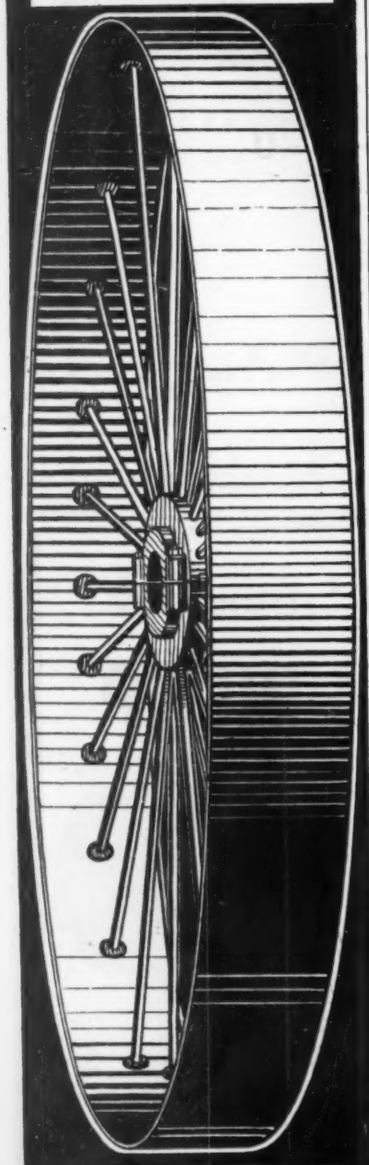

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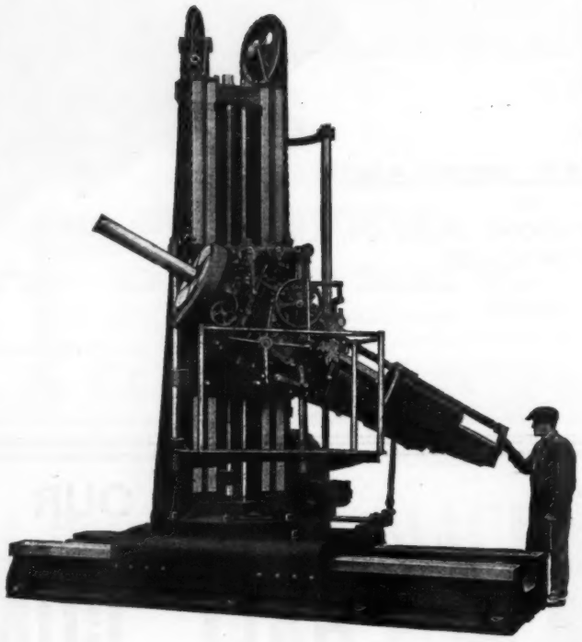

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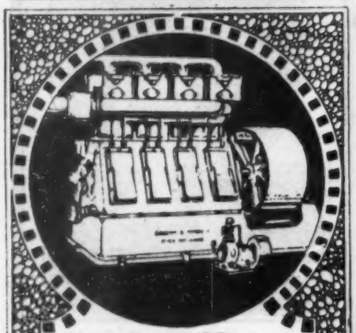

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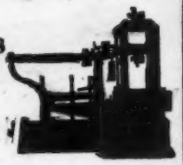

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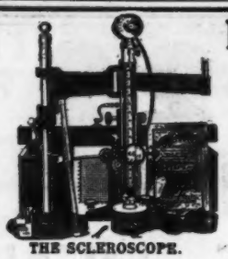

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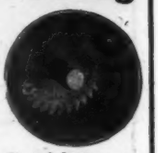

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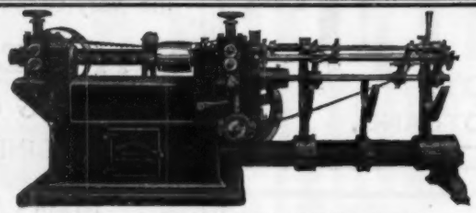

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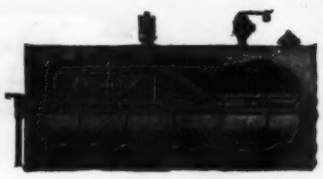

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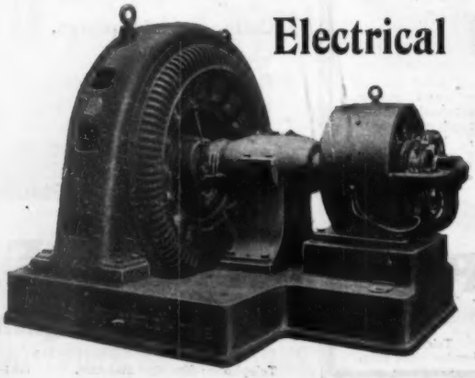

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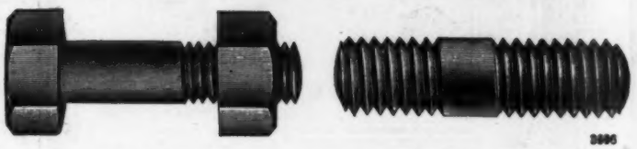

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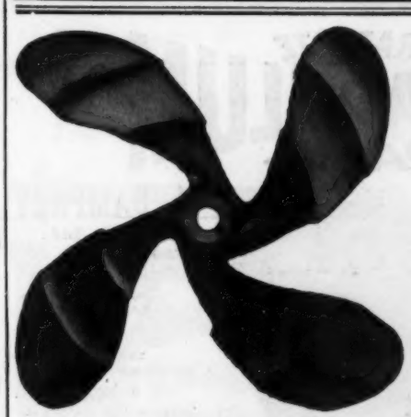

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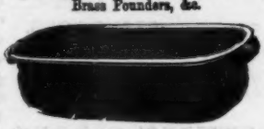

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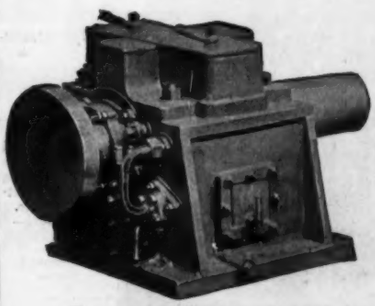

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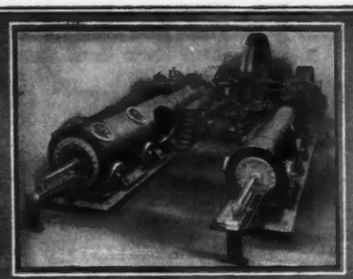

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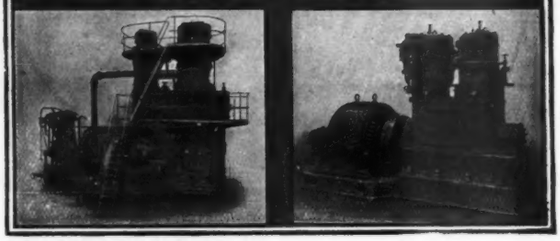

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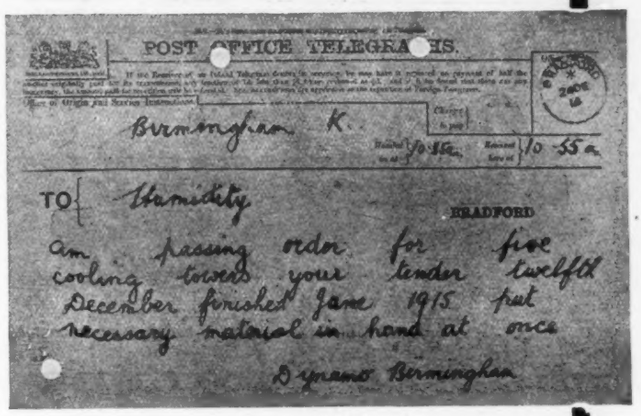
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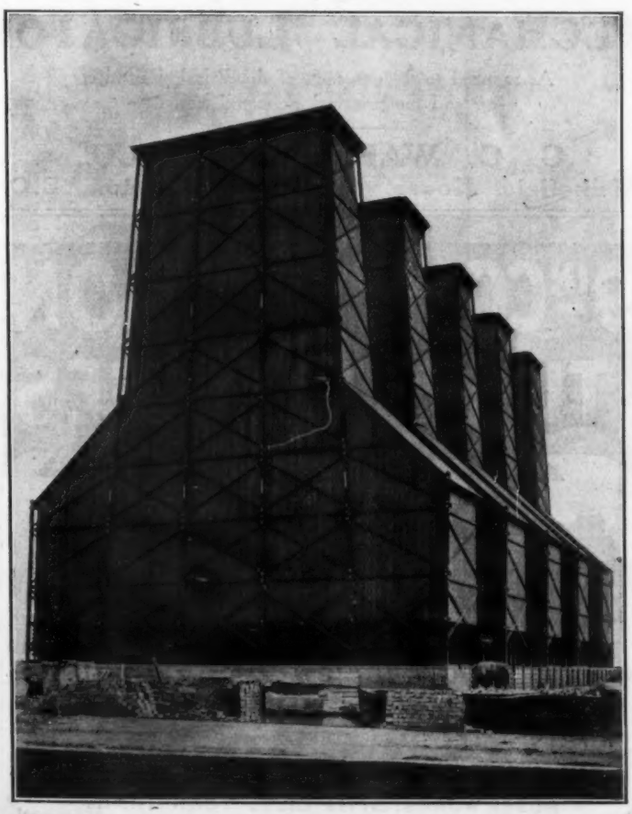

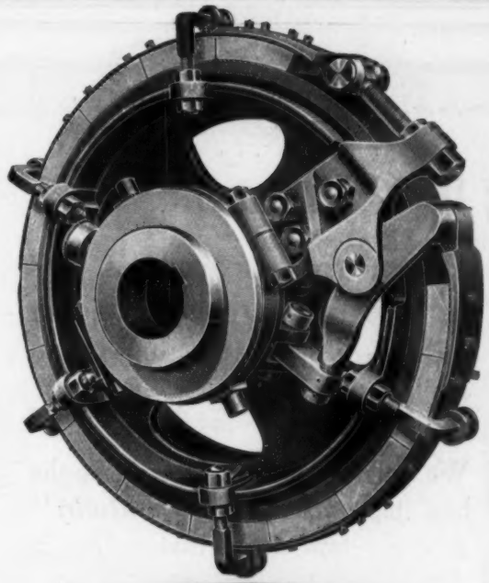

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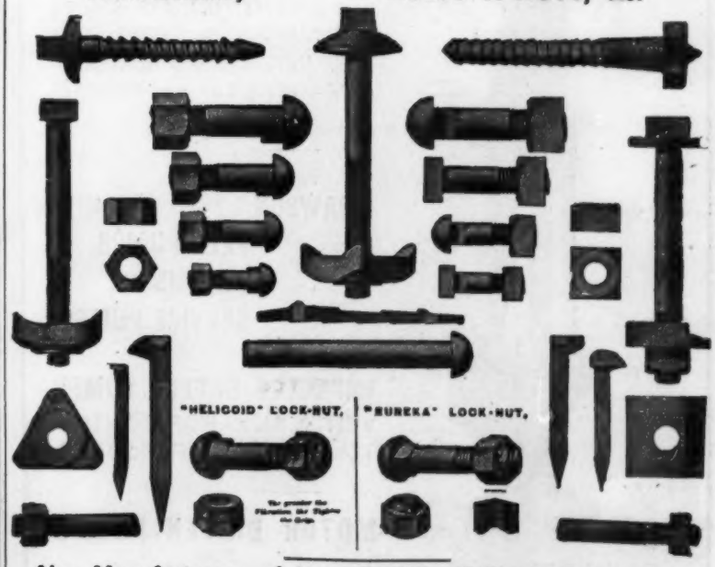

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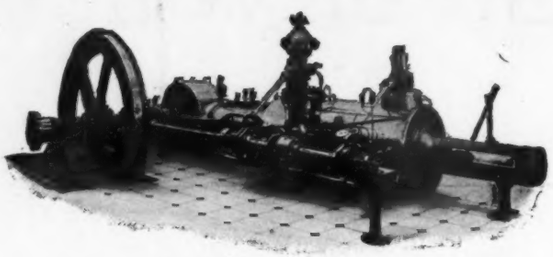

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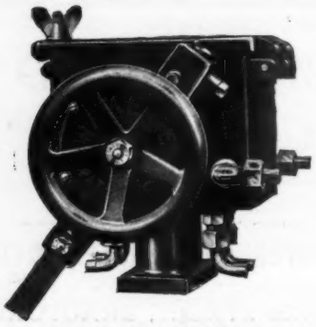

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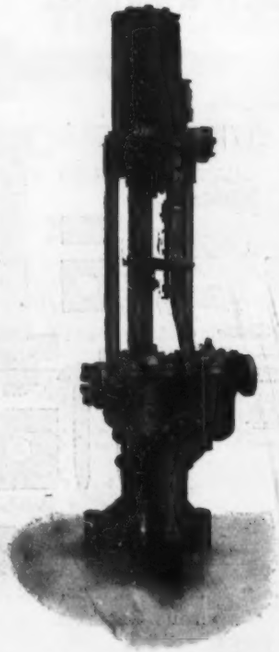

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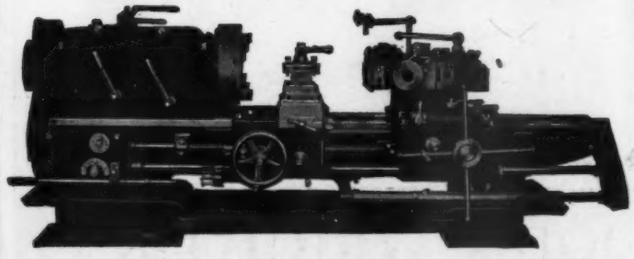

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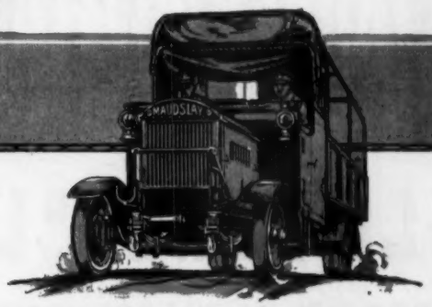

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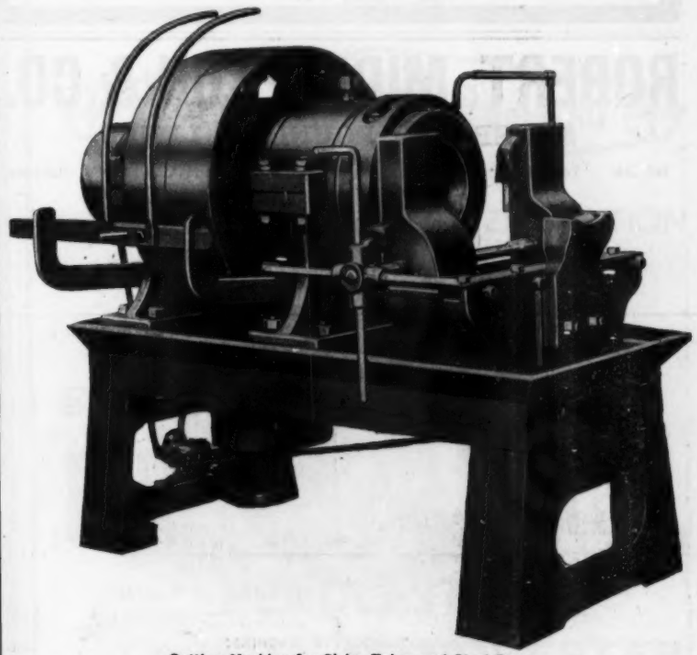

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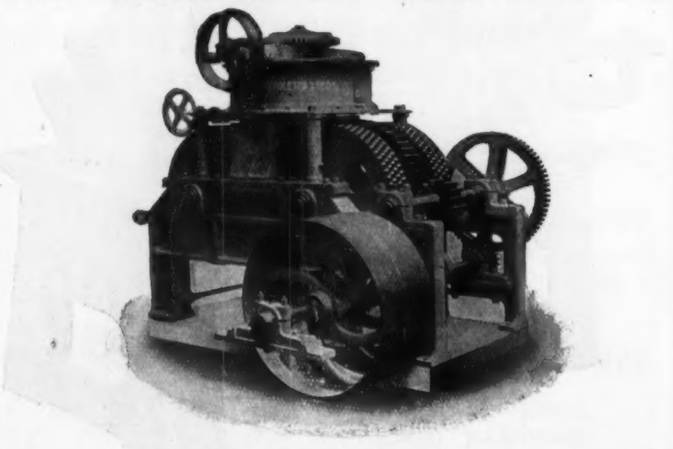

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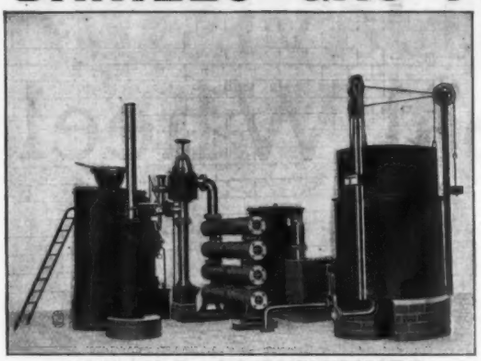

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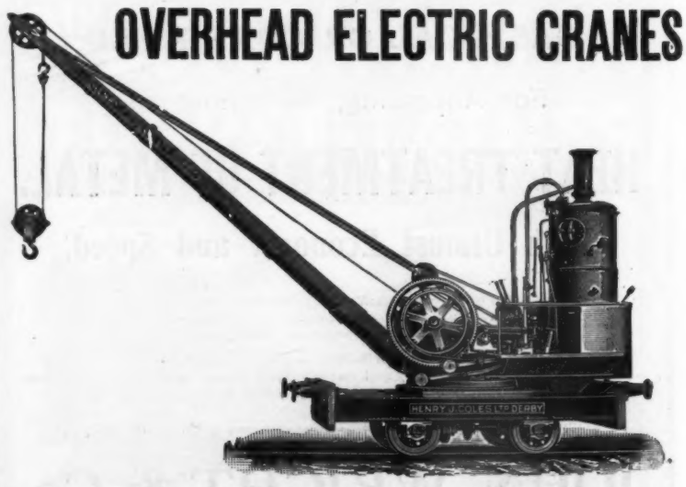

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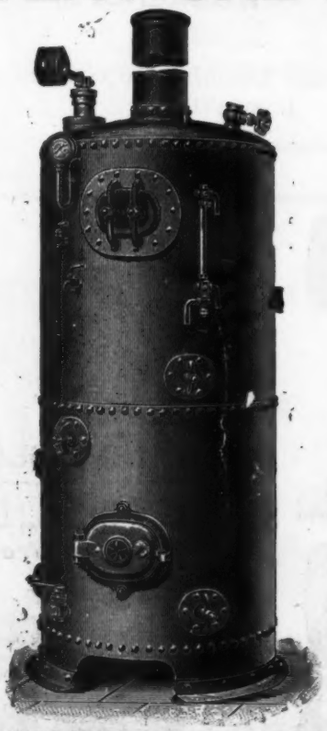

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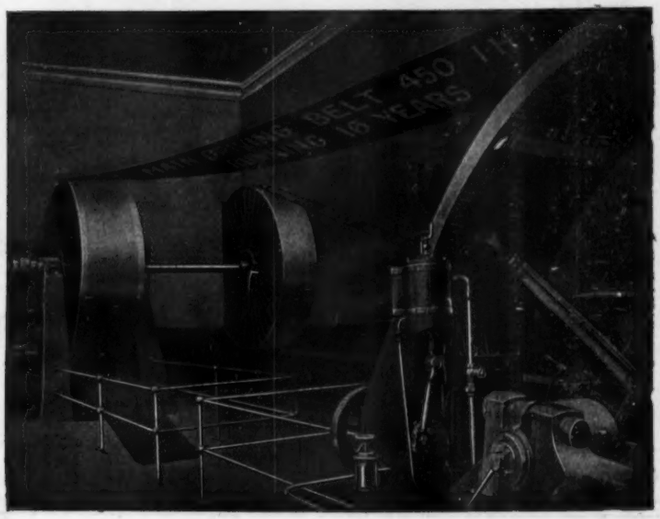

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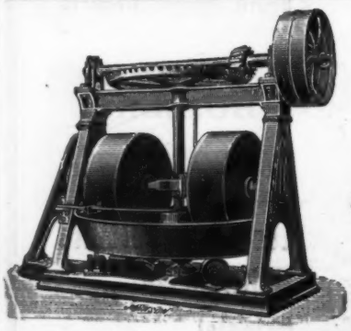

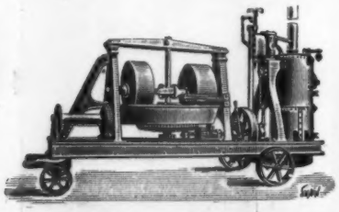

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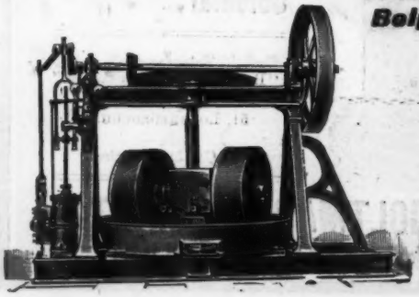

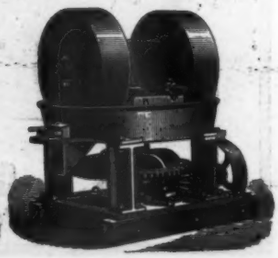

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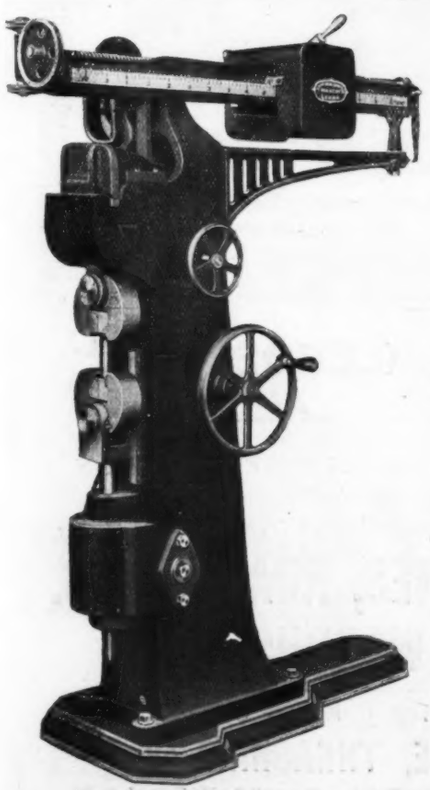

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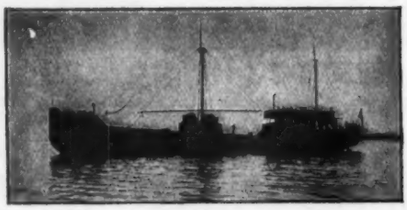

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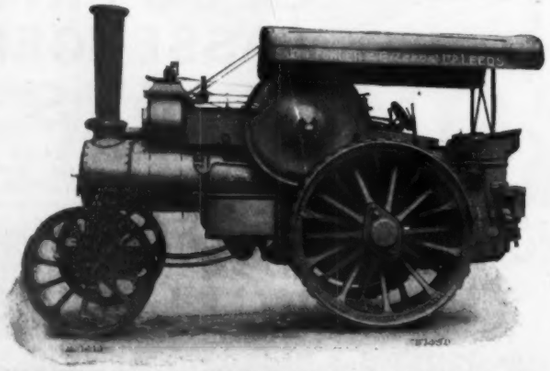

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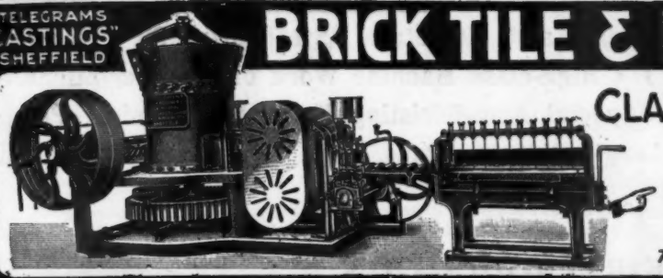

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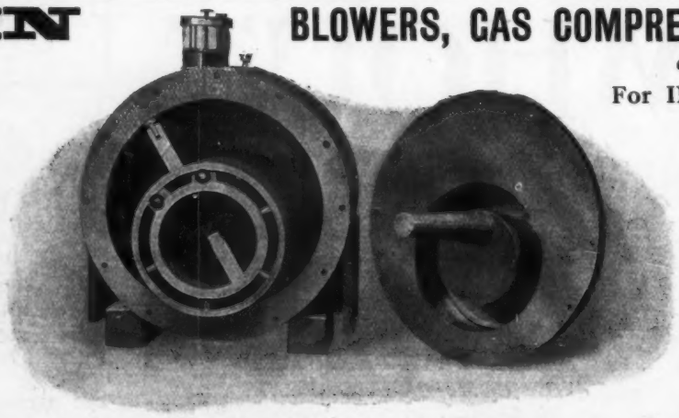

Fig. 659.—View showing Internal Parts of Machine.

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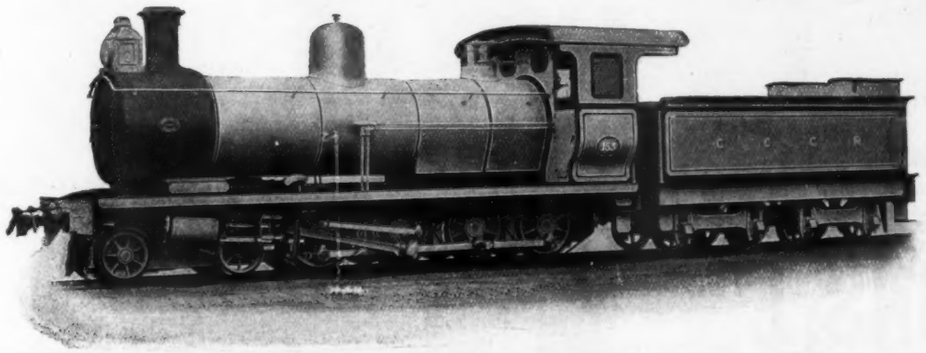

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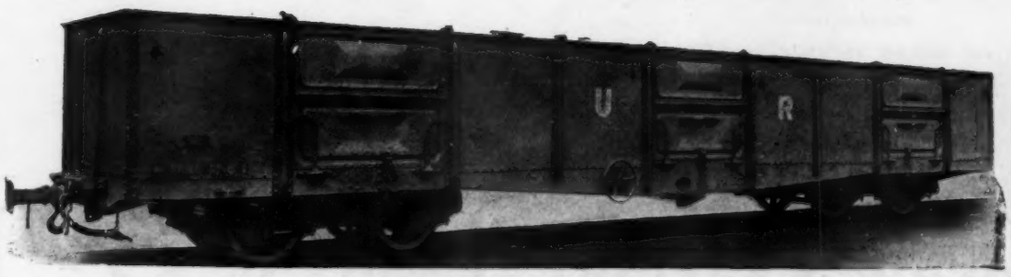

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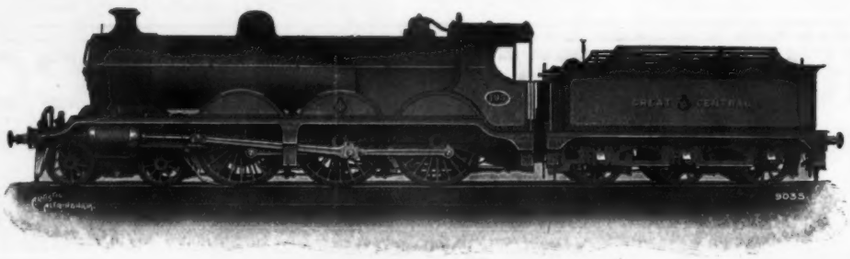

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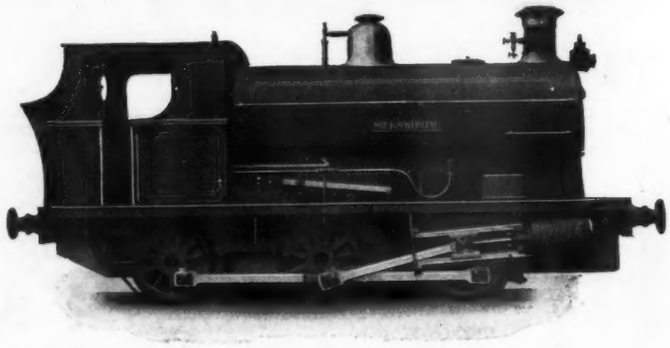

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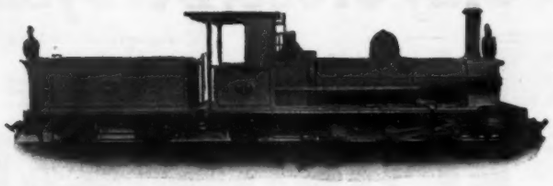

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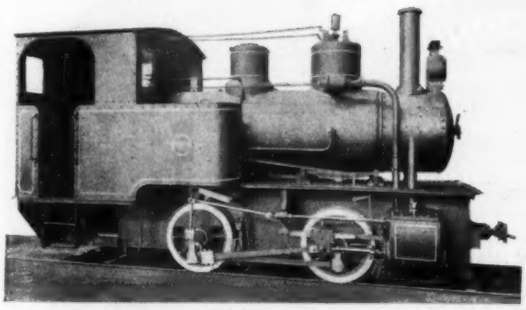

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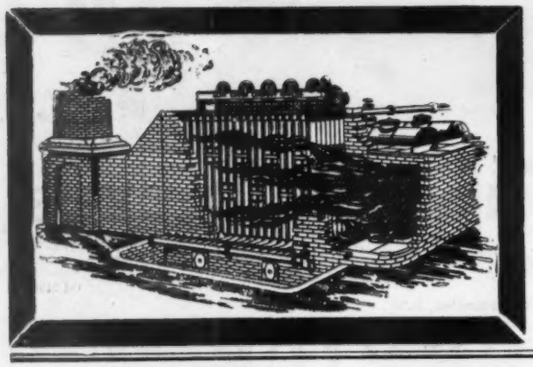

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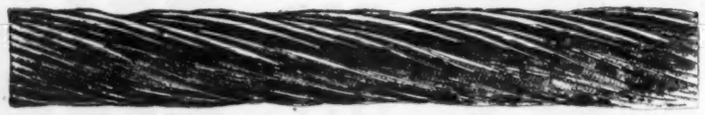

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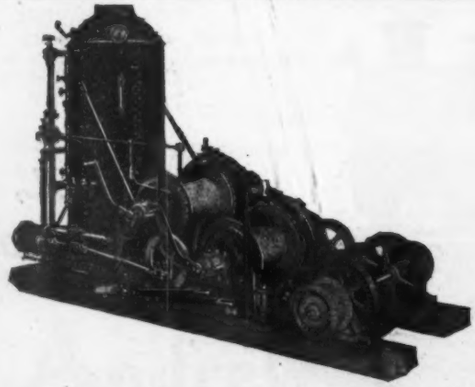

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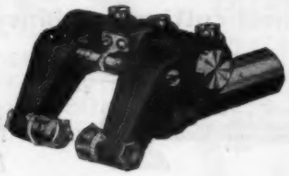

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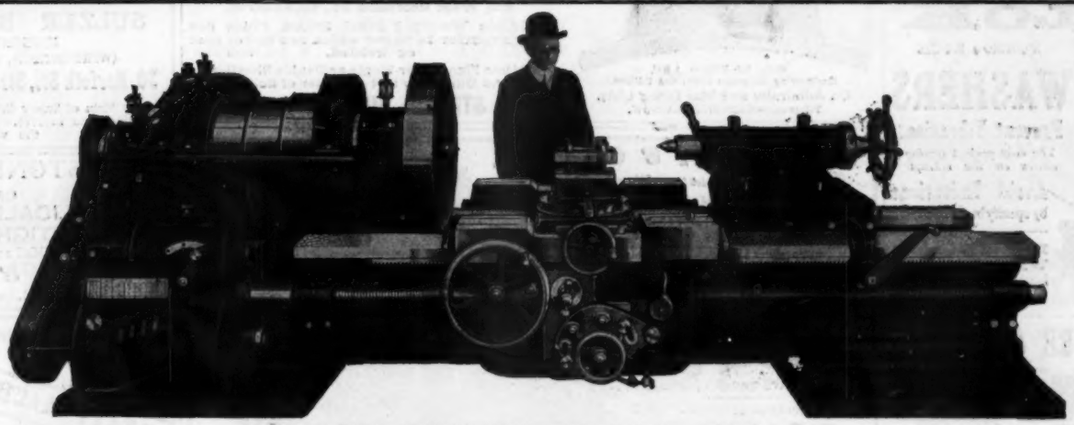

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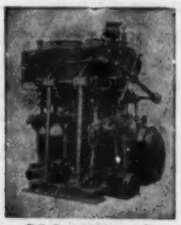

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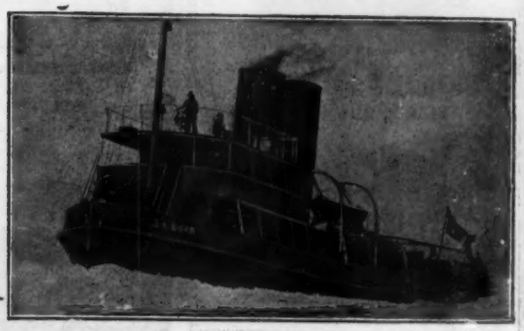

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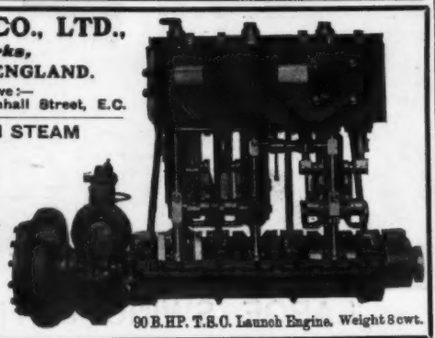
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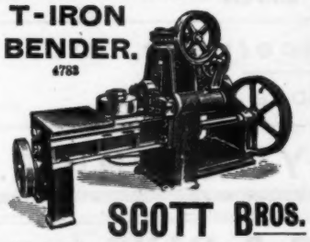

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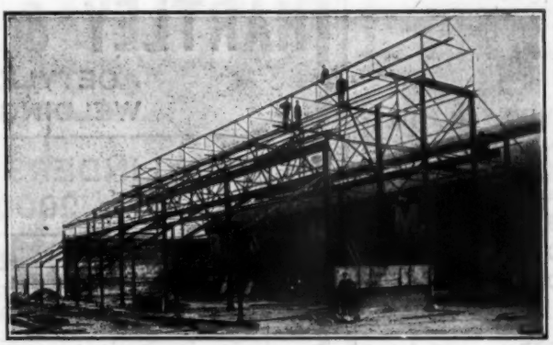

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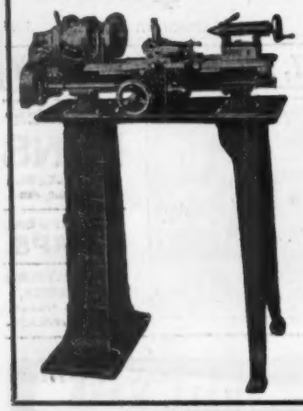

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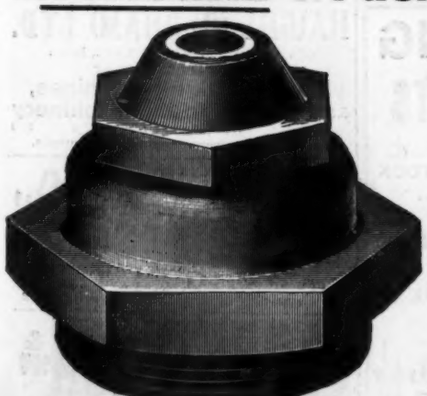

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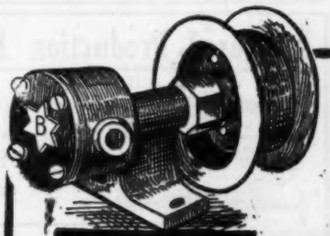

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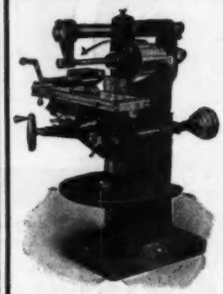
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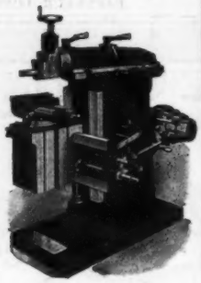
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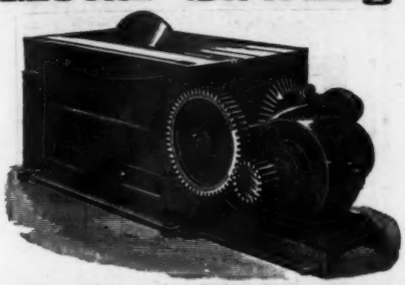

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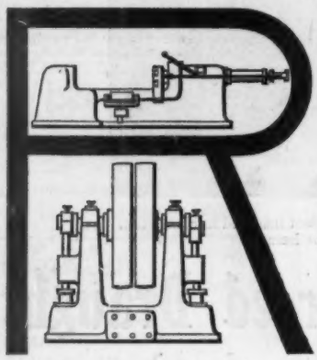

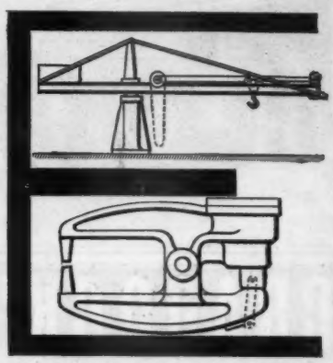

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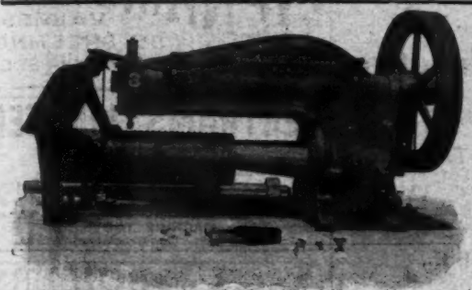

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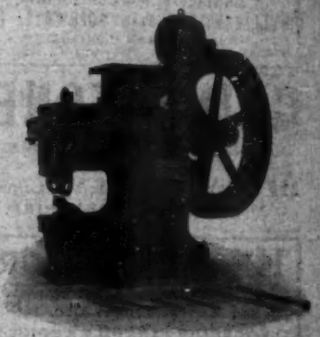

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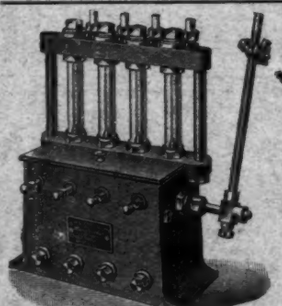

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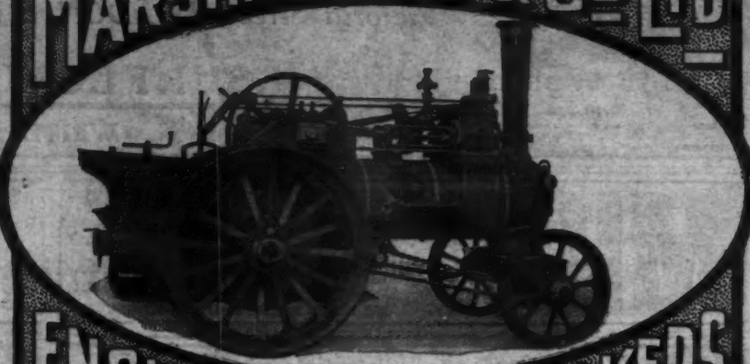

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